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Public Health Service
Washington, D. C.

December 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more extensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations for June 1963 are presented in reports from the Radiation Surveillance Network, the National Air Sampling Network, the Pan American Air Sampling Program, and Canadian Air and Precipitation Surveillance. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 6), which presents data on Canadian and U. S. gross beta radioactivity in air for June. To adjust the data from the two networks to a common baseline, the U. S. data were multiplied by a factor of 1.54, the U. S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

RADIATION SURVEILLANCE NETWORK
June 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are manned by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}-Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}-Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collec-

3

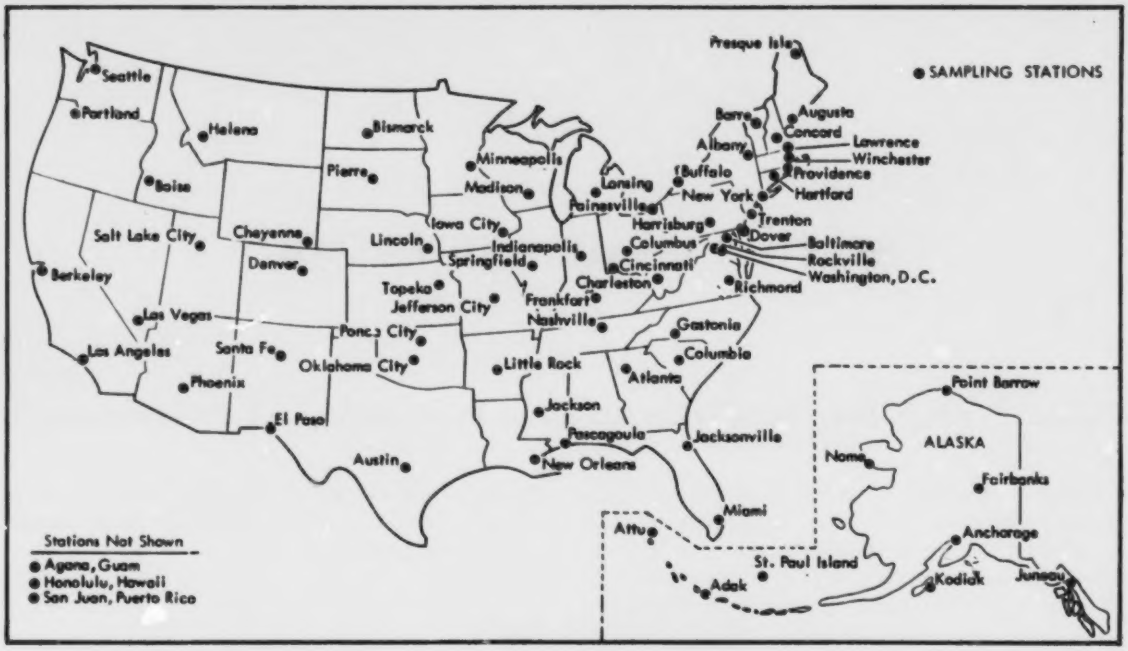
● SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Las Vegas
Ponca City
Nashville
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Pascagoula
Austin
New Orleans
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
Lansing
New York
Hartford
Painesville
Harrisburg
Trenton
Dover
Columbus
Baltimore
Rockville
Cincinnati
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Atlanta
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, JUNE 1963

tion. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2}$ = constant (*1*).[1] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during June 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1. These data (adjusted by the intercalibration factor 1.54),[2] together with corresponding Canadian data, are represented by isogram lines in figure 6 which show the distribution of fission product activity over most of North America.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. June 1963 averages of gross beta activity in precipitation, expressed in picocuries per liter (pc/liter) and nanocuries per square meter (nc/m²), are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, through June 1963, are shown in figure 2.

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review*, *73*:1318–30 (June 1948).
(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D. C. (Distribution by official request).

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[1] In this expression, A is the activity and T is the time after fission product formation.

[2] See reference 1 on page 1–1.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR—RSN, JUNE 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average[1]
Alaska:	Adak	29	5.3	<0.10	1.2
	Anchorage	30	3.1	0.14	1.2
	Attu	30	6.2	0.16	1.8
	Fairbanks	28	5.1	0.16	2.1
	Juneau	10	3.2	0.20	1.1
	Kodiak	29	3.4	<0.10	1.3
	Nome	8	3.0	0.16	1.3
	Point Barrow	11	3.5	<0.10	1.0
	St. Paul Island	30	3.8	<0.10	0.98
Ariz:	Phoenix	30	19	6.2	12
Ark:	Little Rock	29	18	2.0	9.1
Calif:	Berkeley	30	4.6	0.72	2.4
	Los Angeles	20	7.0	1.3	3.9
Colo:	Denver	29	20	3.5	8.5
Conn:	Hartford	30	11	0.25	6.3
Del:	Dover	20	12	1.2	7.5
D.C:	Washington	30	12	0.72	7.0
Fla:	Jacksonville	28	7.5	1.2	3.6
	Miami	30	5.3	0.46	3.0
Ga:	Atlanta	29	11	0.68	6.2
Guam:	Agana	29	3.8	<0.10	0.89
Hawaii:	Honolulu	30	11	1.1	3.4
Idaho:	Boise	30	13	1.0	7.8
Ill:	Springfield	29	14	2.1	7.8
Ind:	Indianapolis	30	12	1.4	9.3
Iowa:	Iowa City	27	9.2	1.4	5.6
Kans:	Topeka	28	12	2.4	6.3
Ky:	Frankfort	29	12	4.0	8.1
La:	New Orleans	29	9.0	0.55	4.1
Maine:	Augusta	30	15	1.7	7.3
	Presque Isle	30	14	0.38	6.0
Md:	Baltimore	19	11	1.0	7.2
	Rockville	17	11	2.8	6.5
Mass:	Lawrence	28	13	1.1	8.3
	Winchester	29	13	0.73	6.5
Mich:	Lansing	30	13	1.4	8.5
Minn:	Minneapolis	29	11	0.45	7.6
Miss:	Jackson	28	13	1.3	6.5
	Pascagoula	14	14	0.99	5.0
Mo:	Jefferson City	30	14	2.2	6.9
Mont:	Helena	30	12	2.2	5.9
Nebr:	Lincoln	12	11	3.1	6.7
Nev:	Las Vegas	29	29	9.6	17
N.H:	Concord	20	20	0.92	10
N.J:	Trenton	30	13	0.53	6.1
N. Mex:	Santa Fe	30	16	3.7	7.8
N.Y:	Albany	27	15	1.4	8.3
	Buffalo	14	13	3.1	9.2
	New York	13	9.6	0.21	4.6
N.C:	Gastonia	29	12	2.2	7.0
N. Dak:	Bismarck	28	12	0.48	6.5
Ohio:	Cincinnati	20	11	2.9	8.1
	Columbus	30	12	3.4	8.3
	Painesville	29	17	2.0	9.6
Okla:	Oklahoma City	28	10	1.4	4.9
	Ponca City	28	6.1	1.7	3.9
Ore:	Portland	29	21	1.4	5.3
Pa:	Harrisburg	26	10	<0.10	5.4
P.R:	San Juan	21	4.2	0.56	2.8
R.I:	Providence	26	15	0.73	7.0
S.C:	Columbia	27	13	1.3	5.7
S. Dak:	Pierre	29	12	0.70	6.6
Tenn:	Nashville	28	14	2.9	9.1
Tex:	Austin	30	9.1	1.2	3.8
	El Paso	30	13	1.8	6.9
Utah:	Salt Lake City	29	16	4.6	9.8
Vt:	Barre	30	16	0.38	9.5
Va:	Richmond	30	8.5	0.46	5.4
Wash:	Seattle	30	8.4	0.63	2.2
W. Va:	Charleston	30	12	1.6	7.3
Wisc:	Madison	30	14	1.1	9.6
Wyo:	Cheyenne	30	23	3.1	9.3
Network		1906	29	<0.10	6.1

[1] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign (<) is placed in front of the average.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION—RSN, JUNE 1963

Station location		Average concentration (pc/liter)	Total deposition[a] (nc/m²)
Alaska:			
	Anchorage	870	21
	Fairbanks	1,200	31
	Juneau	540	34
Ark:	Little Rock	1,000	55
Calif:	Berkeley	[b]—	—
	Los Angeles	6,900	27
Colo:	Denver	2,000	83
Conn:	Hartford	1,700	170
D.C:	Washington	1,600	240
Fla:	Jacksonville	1,000	260
	Miami	570	92
Ga:	Atlanta	—	—
Idaho:	Boise	2,900	190
Ill:	Springfield	2,700	34
Ind:	Indianapolis	3,400	150
Iowa:	Iowa City	—	—
Kan:	Topeka	1,300	120
Ky:	Frankfort	1,900	71
La:	New Orleans	740	140
Maine:	Augusta	2,700	46
	Presque Isle	1,900	75
Md:	Baltimore	1,300	40
Mass:	Lawrence	3,200	94
	Winchester	2,600	115
Mich:	Lansing	1,900	160
Minn:	Minneapolis	3,300	200
Miss:	Jackson	1,000	60
Mo:	Jefferson City	1,400	71
Mont:	Helena	2,900	180
Nebr:	Lincoln	1,300	190
Nev:	Las Vegas	2,100	29
N.J:	Trenton	1,900	23
N. Mex:	Santa Fe	4,700	140
N.Y:	Albany	1,000	34
	Buffalo	—	—
N.C:	Gastonia	540	59
N. Dak:	Bismarck	2,500	340
Ohio:			
	Columbus	2,600	96
	Painesville	2,600	100
Okla:	Oklahoma City	1,300	35
	Ponca City	1,100	81
Ore:	Portland	450	16
Pa:	Harrisburg	1,600	43
P.R:	San Juan	470	29
R.I:	Providence	2,300	80
S.C:	Columbia	420	30
S. Dak:	Pierre	2,500	150
Tenn:	Nashville	1,300	140
Tex:	Austin	490	47
	El Paso	—	—
Utah:	Salt Lake City	3,600	170
Vt:	Barre	2,300	68
Va:	Richmond	560	61
Wash:	Seattle	1,400	54
W. Va:	Charleston	1,400	60
Wisc:	Madison	1,400	110
Wyo:	Cheyenne	2,800	190

[a] Depth of precipitation (mm) $= \dfrac{\text{deposition (nc/m}^2) \times 1000}{\text{concentration (pc/liter)}}$

[b] Dash indicates no evaporated sample received.

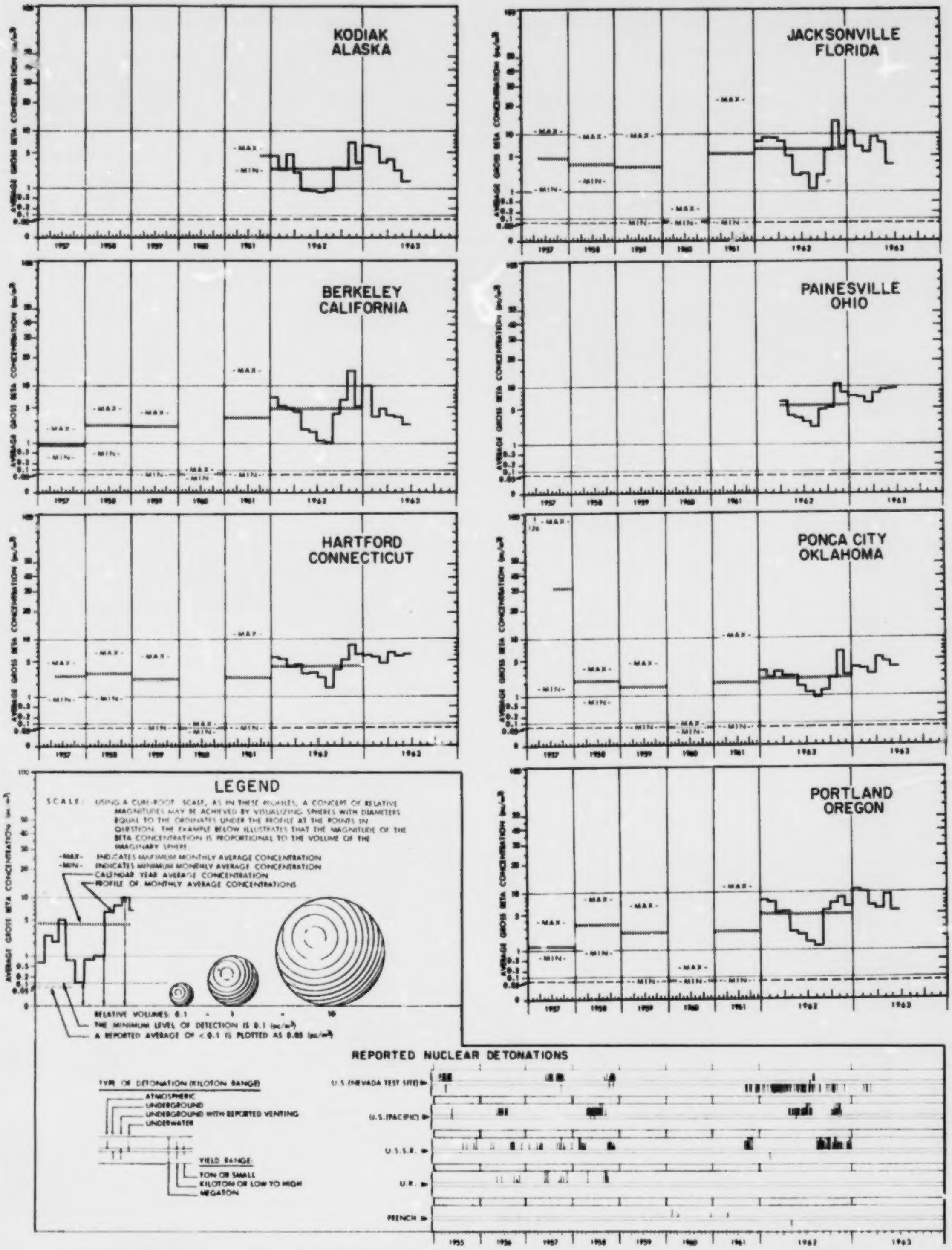

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957–JUNE 1963

NATIONAL AIR SAMPLING NETWORK
Second Quarter 1963

*Division of Air Pollution,
Public Health Service*

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyses air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by coorperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Second quarter 1963 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and anlysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of pre-

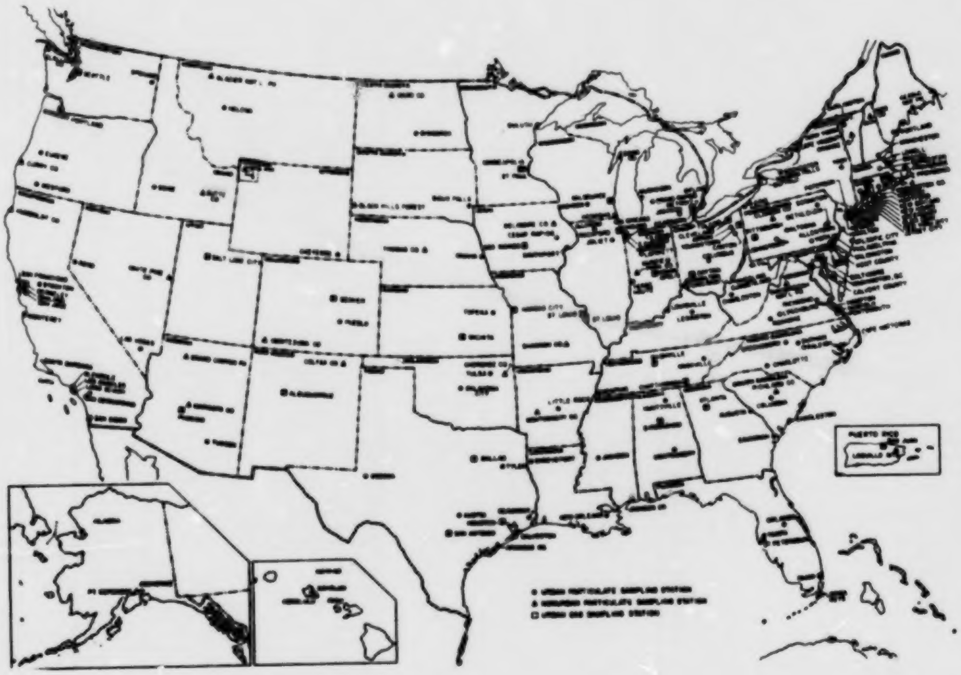

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR—NASN, SECOND QUARTER, 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	7	15.8	8.5	13.6
	Huntsville	7	19.8	7.8	13.6
	Montgomery	7	16.3	7.4	13.5
Alaska:	Anchorage	7	17.6	1.6	6.9
	Pt. Woronzof[1]	6	19.5	1.7	7.1
Ariz:	Grand Canyon Pk.[1]	6	32.0	9.9	20.4
	Maricopa County	7	29.7	7.5	18.0
	Phoenix	6	23.8	6.9	15.6
	Tucson	7	30.4	8.2	16.5
Ark:	Little Rock	3	14.3	7.0	9.9
	Montgomery County[1]	6	19.2	3.8	12.4
Calif:	Berkeley	5	7.7	2.3	5.1
	Glendale	7	27.0	7.5	13.9
	Humboldt County[1]	5	5.9	1.6	4.1
	Long Beach	7	19.8	3.6	9.0
	Los Angeles	7	19.9	4.8	11.8
	Monterey	6	10.1	4.4	7.3
	Oakland	6	14.3	5.7	9.4
	San Bernardino	7	25.0	11.0	16.0
	San Diego	6	19.4	2.7	8.1
	San Francisco	7	16.0	3.4	7.5
	San Jose	7	12.4	3.2	7.7
	Santa Barbara	7	13.8	3.4	8.6
	Stockton	7	12.4	2.9	8.8
Colo:	Denver	7	27.7	6.6	14.3
	Montezuma County[1]	6	22.0	9.4	15.3
	Pueblo	7	29.6	4.0	14.8
Conn:	Hartford	7	23.2	5.0	11.5
	New Britain	4	15.4	5.0	9.2
	New Haven	7	21.6	4.0	12.1
	Norwich	7	30.0	4.5	12.8
	Waterbury	7	14.9	3.5	7.9
	Kent County[1]	3	12.0	9.4	11.0
	Wilmington	7	16.5	8.7	12.0
D.C:	Washington	7	28.5	9.9	15.2
Fla:	Florida Keys[1]	6	18.6	4.6	10.7
	Miami	7	23.4	3.8	13.5
	Orlando	6	17.5	2.5	9.8
	St. Petersburg	6	21.6	6.3	12.6
	Tampa	6	18.5	3.7	10.6
Ga:	Atlanta	7	16.0	11.3	13.6
	Augusta	6	17.9	8.9	12.0
	Savannah	7	19.2	2.7	11.2
Hawaii:	Honolulu	7	5.6	1.8	4.3
	Kahaluu[1]	6	9.7	3.0	5.6
Idaho:	Boise	6	12.3	2.8	8.2
	Butte County[1]	5	30.0	9.4	18.0
Ill:	Chicago	6	16.4	6.6	12.9
	East St. Louis	5	13.8	7.4	11.0
	Joliet	7	19.1	4.8	11.9
	North Chicago	7	27.3	5.9	11.9
	Rockford	4	18.2	11.9	13.9
Ind:	East Chicago	4	13.3	0.4	8.3
	Hammond	7	16.3	4.9	11.9
	Indianapolis	7	20.0	8.8	14.4
	Muncie	7	20.7	3.5	13.7
	Parke County[1]	6	17.3	6.5	12.8
	South Bend	7	19.4	4.1	12.4
	Terre Haute	7	22.6	5.4	14.4
Iowa:	Cedar Rapids	7	14.9	6.4	10.8
	Davenport	6	49.3	1.3	16.5
	Delaware County[1]	5	15.0	6.8	9.8
	Des Moines	6	22.6	8.1	12.3
Kans:	Topeka	7	13.2	4.2	8.4
	Wichita	7	19.0	5.4	11.7
Ky:	Lexington	5	16.5	9.3	14.2
	Louisville	6	19.1	7.1	13.6
La:	New Orleans	7	17.5	3.6	11.8
	Shreveport	4	17.8	12.5	15.4
Maine:	Acadia Nat'l. Park[1]	4	6.0	1.0	4.2
	Portland	7	15.5	4.8	9.2
Md:	Baltimore	7	15.6	9.2	12.3
	Calvert County[1]	6	15.0	10.0	12.3
	Cumberland	7	19.6	4.4	12.5
Mass:	Boston	6	16.8	3.1	9.2
	Lowell	7	29.6	10.4	18.0
	Worcester	7	19.3	4.8	10.5
Mich:	Dearborn	7	21.3	4.2	11.6
	Detroit	7	17.2	3.8	10.7
	Flint	7	13.5	3.2	9.0
	Grand Rapids	6	17.4	2.8	11.9
	Jackson	7	20.4	3.5	13.0
	Muskegon	7	17.8	3.2	10.0
Minn:	Duluth	6	18.3	1.8	10.4
	Minneapolis	7	16.4	6.5	11.7
	St. Paul	7	20.9	7.7	13.4
Miss:	Jackson	6	18.4	4.9	13.0
	Jackson County[1]	5	18.0	4.0	10.1
Mo:	Kansas City	6	13.9	3.6	10.4
	Shannon County[1]	5	18.0	11.8	14.2
	St. Louis	7	17.8	5.4	11.8
Mont:	Glacier Nat Pk[1]	6	19.2	4.0	9.9
	Helena	7	22.6	4.3	11.0
Nebr:	Omaha	7	13.3	1.0	8.7
	Thomas County	6	18.2	7.7	11.1
Nev:	Las Vegas	5	34.1	17.1	25.3
	Reno	5	18.5	10.5	15.0
	White Pine County[1]	6	24.5	14.0	18.5
N.H:	Coos County[1]	5	14.4	5.1	9.9
N.J:	Atlantic City	7	14.6	6.9	10.7
	Bayonne	6	19.8	3.8	10.5
	Hamilton	6	16.6	6.7	11.9
	Jersey City	6	32.6	3.7	12.2
	Newark	7	18.0	8.3	12.7
	Paterson	7	22.0	3.6	12.[illegible]
N. Mex:	Albuquerque	7	15.6	5.0	10.7
	Colfax County[1]	6	13.6	0.4	[illegible].9
N.Y:	Cape Vincent[1]	6	18.6	4.9	10.5
	Glen Cove	5	10.8	3.7	8.4
	Massena	7	17.9	3.7	10.8
	New York City	7	24.2	7.8	16.5
	Niagara Falls	7	17.8	5.5	11.5
	Rochester	7	16.0	5.7	10.8
	Troy	4	14.4	2.9	10.9
N.C:	Cape Hatteras[1]	5	16.7	6.3	12.4
	Charlotte	7	18.6	9.2	12.7
	Durham	7	19.7	6.6	12.3
	Greensboro	7	26.0	9.8	15.1
	Raleigh	7	18.5	4.1	10.4
N. Dak:	Bismarck	7	17.6	4.9	9.6
	Ward County[1]	7	16.0	5.2	9.6
Ohio:	Akron	7	16.9	6.8	12.9
	Canton	7	14.4	2.2	10.3
	Cincinnati	7	17.6	8.3	14.3
	Cleveland	6	18.8	4.7	13.0
	Columbus	7	16.4	7.2	13.0
	Dayton	7	18.4	7.9	14.2
	Hamilton	7	19.4	8.3	15.4
	Toledo	7	19.3	4.8	12.7
	Youngstown	7	15.5	8.4	12.1
Okla:	Cherokee County[1]	6	14.1	3.4	9.4
	Oklahoma City	6	13.8	4.1	9.6
	Tulsa	7	17.5	4.3	10.6
Ore:	Curry County[1]	5	8.9	1.9	5.5
	Eugene	6	5.5	2.9	4.3
	Medford	7	9.2	0.7	5.0
	Portland	7	[illegible].8	3.1	5.1
Pa:	Allentown	7	14.2	4.8	9.7
	Altoona	6	14.4	10.0	12.1
	Bethlehem	7	15.7	5.3	10.8
	Clarion County[1]	5	15.4	7.0	11.0
	Erie	7	20.7	2.4	12.5
	Johnstown	6	13.0	7.6	10.1
	Philadelphia	7	15.6	8.0	11.9
	Pittsburgh	6	15.7	7.6	11.3
	Scranton	7	24.1	3.2	12.0
	York	7	22.0	8.2	15.2
P.R.:	San Juan	4	9.2	5.2	6.9
R.I:	East Providence	7	16.8	2.9	11.3
	Providence	5	17.1	3.7	9.9
	Washington County[1]	6	24.6	3.9	12.1
S.C:	Charleston	7	15.4	1.9	11.4
	Columbia	6	13.2	4.5	9.2
	Richland County[1]	6	21.8	11.5	15.6
S. Dak:	Black Hills Forest[1]	6	23.0	4.6	11.5
	Sioux Falls	6	13.5	4.8	10.2
Tenn:	Chattanooga	6	18.4	2.9	10.2
	Knoxville	7	14.5	10.2	12.6
	Memphis	7	15.9	4.6	12.9
	Nashville	7	21.0	7.5	13.9
Tex:	Arkansas County[1]	6	16.9	4.9	11.1
	Austin	7	22.2	4.2	12.6
	Beaumont	3	21.5	2.8	11.0
	Dallas	6	16.6	2.5	9.4
	Galveston	4	15.0	9.6	12.9
	Houston	7	16.7	2.9	11.1
	Odessa	6	13.8	4.6	8.5
	San Antonio	7	13.6	1.5	9.5
	Tyler	7	22.8	3.2	13.2
Utah:	Salt Lake City	7	26.4	10.8	18.5
Vt:	Burlington	5	18.0	5.9	11.1
	Orange County[1]	6	17.6	4.6	10.7
Va:	Hampton	7	12.2	5.0	10.0
	Lynchburg	6	21.3	11.3	14.6
	Norfolk	7	14.7	6.3	12.1
	Portsmouth	6	12.9	5.8	10.1
	Richmond	7	13.6	5.3	10.2
	Roanoke	6	18.1	8.4	14.2
	Shenandoah Nat'l Park[1]	6	16.0	7.8	12.7
Wash:	Clallam County[1]	7	10.0	2.1	5.6
	Seattle	7	8.8	2.7	5.9
	Spokane	7	19.6	1.5	10.7
W. Va:	Charleston	7	21.4	6.5	13.7
	Wheeling	7	21.3	6.6	12.7
Wis:	Door County[1]	7	17.8	6.2	11.7
	Kenosha	7	17.6	3.8	11.5
	Madison	7	18.7	6.4	11.7
	Milwaukee	7	16.0	5.3	10.1
Wyo:	Cheyenne	5	41.6	10.7	23.6
	Yellowstone Park[1]	6	24.6	10.8	17.0
Network		1202	49.3	0.4	11.6

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[1] Nonurban station.

TABLE 4.—FISSION PRODUCT BETA ACTIVITY IN PRECIPITATION—NASN, SECOND QUARTER 1963

Station		April		May		June	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Alabama:	Montgomery	—	—	540	38	540	59
California:	Santa Maria	810	73	—	—	—	—
Florida:	Tampa	—	—	—	—	630	28
Idaho:	Pocatello	1260	63	—	—	2100	105
Illinois:	Chicago (Midway)	2380	265	—	—	—	—
	Chicago (O'Hare)	2600	301	2200	89	—	—
Louisiana:	Lake Charles	—	—	—	—	400	27
Maine:	Caribou	1830	103	1440	64	—	—
Massachusetts:	Nantucket	2500	103	990	108	2920	113
Michigan:	Sault Ste. Marie	—	—	1500	93	2540	120
Minnesota:	St. Cloud	5080	383	1840	199	2110	133
Missouri:	Columbia	1430	70	1430	168	780	56
Montana:	Glasgow	—	—	—	—	1240	119
Nebraska:	Grand Island	—	—	1000	73	2230	123
North Carolina:	Cape Hatteras	715	118	1180	120	670	93
Ohio:	Cincinnati (Airport)	2580	109	1780	118	—	—
	Cincinnati (Gest St.)	—	—	2500	205	—	—
Pennsylvania:	Philadelphia	—	—	—	—	1800	128
South Carolina:	Charleston	1220	84	—	—	180	65
	Greenville	1170	165	2060	164	1290	154
Tennessee:	Nashville	2060	116	2000	85	1270	78
Texas:	Amarillo	—	—	1570	95	1060	53
	Brownsville	—	—	970	70	230	14
	San Angelo	—	—	1040	92	770	33
Virginia:	Sterling	—	—	—	—	740	98
Washington:	Tatoosh	1120	89	560	24	—	—

cipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the second quarter 1963 are presented in table 4.

9

CANADIAN AIR AND PRECIPITATION SURVEILLANCE
June 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 4) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (1–5).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission prod-

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR—RFSP, JUNE 1963

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	30	27.5	0.4	11.9
Coral Harbour	25	12.6	0.4	3.8
Edmonton	30	23.2	4.0	11.2
Ft. Churchill	29	12.0	0.1	4.6
Ft. William	30	18.3	1.1	10.1
Fredericton	30	24.4	1.1	7.6
Goose Bay	30	18.7	0.1	7.2
Halifax	29	18.7	0.2	6.8
Inuvik	30	11.9	0.3	4.6
Montreal	29	21.7	0.8	11.9
Moosonee	30	21.8	1.2	9.2
Ottawa	26	20.3	2.5	13.8
Quebec	30	19.0	0.7	10.1
Regina	30	25.0	0.5	10.0
Resolute	28	6.7	0.7	2.9
St. John's, Nfld.	30	11.1	0.3	4.9
Saskatoon	30	28.1	0.8	10.8
Sault Ste. Marie	29	21.3	3.8	11.4
Toronto	30	19.4	0.8	11.5
Vancouver	30	17.4	1.0	5.0
Whitehorse	30	15.7	0.5	5.1
Windsor	27	20.4	1.8	12.4
Winnipeg	30	19.4	1.3	11.0
Yellowknife	28	15.0	0.2	6.7
Network		28.1	0.1	8.5

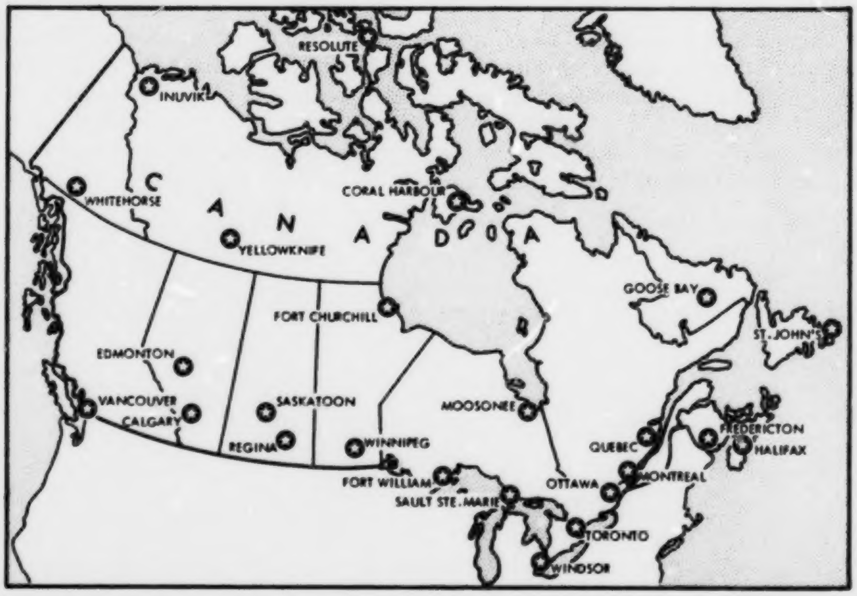
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, JUNE 1963

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TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION—RFSP, JUNE 1963

Station	Total beta activity	
	pc/liter	nc/m^2
Calgary	4,050	592
Coral Harbour	3,470	87.2
Edmonton	6,500	357
Ft. Churchill	6,000	193
Ft. William	3,690	398
Fredericton	2,950	137
Goose Bay	2,080	336
Halifax	2,960	140
Inuvik	3,460	75.6
Montreal	2,950	270
Moosonee	4,300	238
Ottawa	6,520	190
Quebec	5,590	240
Regina	2,440	283
Resolute	1,370	101
St. John's, Nfld	2,590	223
Saskatoon	3,680	343
Sault Ste. Marie	5,110	265
Toronto	4,340	82.5
Vancouver	2,050	87.2
Whitehorse	3,240	106
Windsor	2,380	295
Winnipeg	3,490	304
Yellowknife	5,250	148
Average	3,770	229

ucts The results are extrapolated to the end of the sampling period. Canadian air data for June 1963 are given in table 5 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container the polythene liner is removed, packed with the sample, and sent to the laboratory. Beta activities in precipitation for stations in Canada are presented in table 6. Radiochemical analyses of these samples are given on page 498 under the subsection on fallout.

REFERENCES

(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3,* Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4,* Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5,* Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11,* Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21,* Department of National Health and Welfare, Ottawa, Canada (August 1962).

PAN AMERICAN SAMPLING PROGRAM
June 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is being monitored at three locations in South America under the auspices of a collaborative radiological health program between the Pan American Health Organization (PAHO) and the Public Health Service (PHS).

The three air sampling stations presently included in the program are located in Santiago, Chile; Lima, Peru; and Caracas, Venezuela. The Caracas station was activated in November 1962 and the other two stations entered in December of the same year.

The air sampling stations are manned by local personnel, and the sampling equipment and laboratory analyses are provided by the Public Health Service. Equipment and counting procedures are identical with those employed for the Radiation Surveillance Network.

Fission product gross beta activity for June 1963 are presented in table 7. Monitoring results for November 1962–June 1963 are summarized in figure 5.

The higher monthly average values noted for Caracas, in comparison with values for corresponding months for Lima and Santiago, are consistent with the Northern Hemisphere location of the Caracas station.

TABLE 7—GROSS BETA ACTIVITY IN AIR—PASP, JUNE 1963

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average[1]
Caracas, Venezuela	20	2.4	<0.10	0.72
Lima, Peru[2]	0	—	—	—
Santiago, Chile	3	0.16	<0.10	<0.12

[1] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign (<) is placed in front of the average.

[2] The Lima, Peru station was not in operation during the months of May and June because of mechanical difficulties.

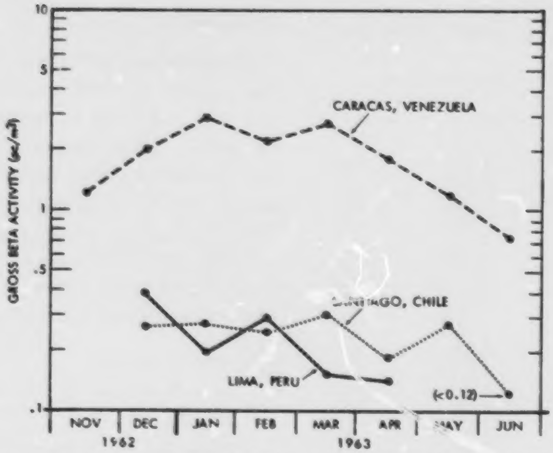

FIGURE 5.—GROSS BETA ACTIVITY IN AIR PAN AMERICAN SAMPLING PROGRAM

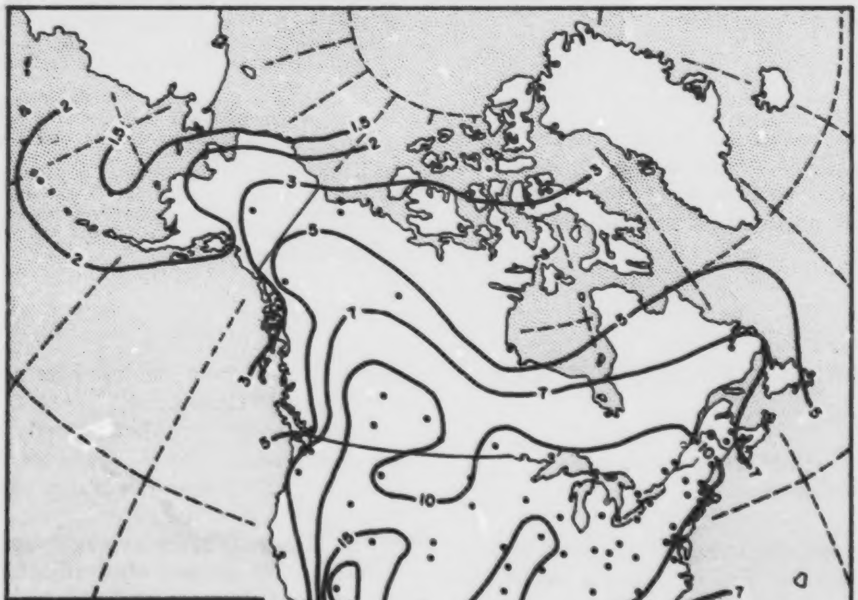
2
1.5
1
3
5
7
10
15
20
LEGEND
⊙ Sampling Stations:
Canadian Air Network
Radiation Surveillance Network
Pan-American Sampling
Program(part)
Concentration Isogram Values:
1-1.5-2-3-5-7-10-
15-20-30-50-70-100
in pc/m³
0 200 400 600 800
Scale in Miles

FIGURE 6.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAM VALUES FOR CANADA AND THE U.S., JUNE 1963

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Fission Product Gamma Activity in Airborne Particulates

THE 80TH MERIDIAN NETWORK
May 1963

Health and Safety Laboratory
Atomic Energy Commission

Surface air filter samples collected at the 80th Meridian Network stations (see figure 1) since January 1, 1963 have been assayed for gross fission product activity by means of gamma rather than beta measurements. This method was discussed in detail in an earlier report (*1*). It was shown that for a sample of neutron-irradiated U^{235}, representing unfractionated fission products, the ratio of hard gamma photons (over 1 Mev) to total gamma photons ratio was nearly constant at 0.011 when the sample had aged more than four months. Younger fission products showed a higher ratio. The method for estimating the gross beta activity was also discussed.

At each station about 1400 cubic meters of air per day are drawn through 8-inch diameter

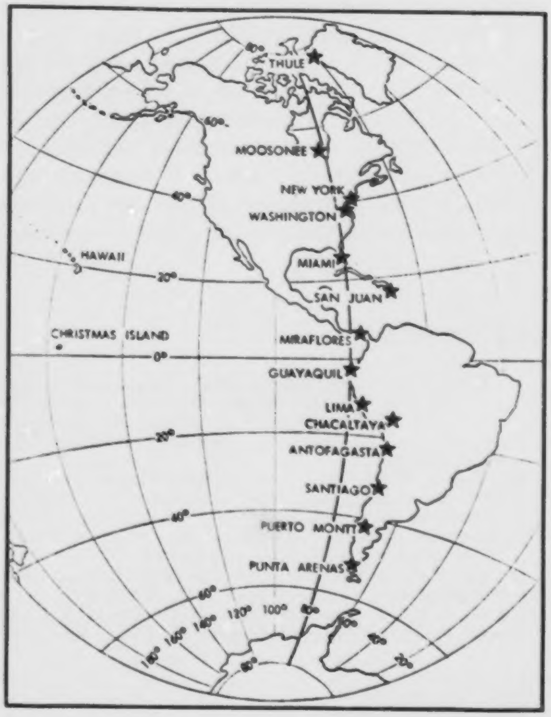

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—ACTIVITY OF SURFACE AIR—80TH MERIDAN NETWORK, MAY 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m^3)		Gamma photon ratio $\left(\frac{\gamma > 1\ \text{Mev}}{\text{total}\ \gamma}\right)$	Estimated total beta activity (pc/m^3)
		Filter	Average for month		
Thule	1-8	10.1		0.024	6.8
	8-15	6.52		0.022	4.4
	15-22	4.40		0.024	3.0
	22-6/1	5.39	6.60	0.024	3.6
Moosonee	1-8	10.5		0.023	7.1
	8-15	8.04		0.024	5.4
	15-22	4.91		0.022	3.3
	22-6/1	9.61	8.27	0.024	6.5
New York	1-8	10.7		0.023	7.2
	8-15	7.98		0.021	5.4
	15-22	8.22		0.023	5.5
	22-6/1	4.80	7.93	0.022	3.2
Washington	1-8	10.9		0.022	7.4
	8-15	8.01		0.022	5.4
	15-22	7.92		0.023	5.4
	22-6/1	12.7	9.88	0.023	8.6
Miami	1-8	10.9		0.016	7.4
	8-15	12.4		0.024	8.4
	15-22	10.6		0.022	7.2
	22-6/1	5.44	9.84	0.022	3.7
Mauna Loa	1-8	4.05		0.023	2.7
	8-15	4.11		0.023	2.8
	15-22	2.71		0.034	1.8
	22-6/1	4.38	3.81	0.027	3.0
San Juan	1-8	2.79		0.025	1.9
	8-15	2.47		0.024	1.7
	15-22	2.73		0.025	1.8
	22-6/1	4.39	3.10	0.026	3.0
Miraflores	1-8	3.61		0.025	2.4
	8-15	1.71		0.024	1.2
	15-22	0.636		0.030	0.43
	22-6/1	0.728	1.67	0.024	0.49
Guayaquil	1-8	0.287		0.015	0.15
	8-15	0.161		0.025	0.11
	15-22	0.0929		0.012	0.06
	22-6/1	0.0689	0.137	0.012	0.05
Lima	1-8	0.0881		0.020	0.06
	8-15	0.181		0.047	0.12
	15-22	0.0771		0.033	0.05
	22-6/1	0.0451	0.0978	0.012	0.03
Chacaltaya	1-8	0.0904		0.034	0.06
	8-15	0.0611		0.033	0.04
	15-22	0.127		0.059	0.09
	22-6/1	0.156	0.109	0.030	0.10
Antofagasta	1-8	0.159		0.026	0.11
	8-15	0.131		0.067	0.09
	15-22	0.0737		0.036	0.05
	22-6/1	0.0890	0.113	0.045	0.06
Santiago	1-8	0.0670		0.012	0.04
	8-15	0.102		0.049	0.07
	15-22	0.0941		0.033	0.06
	22-6/1	0.0775	0.0851	0.042	0.05
Puerto Montt	1-8	0.0493		0.053	0.03
	8-15	0.0391		0.019	0.03
	15-22	0.0670		0.012	0.04
	22-6/1	0.0560	0.0529	0.033	0.04
Punta Arenas	1-8	0.0441		0.043	0.03
	8-15	0.0345		0.018	0.02
	15-22	0.0616		0.051	0.04
	22-6/1	0.0348	0.0438	0.032	0.02

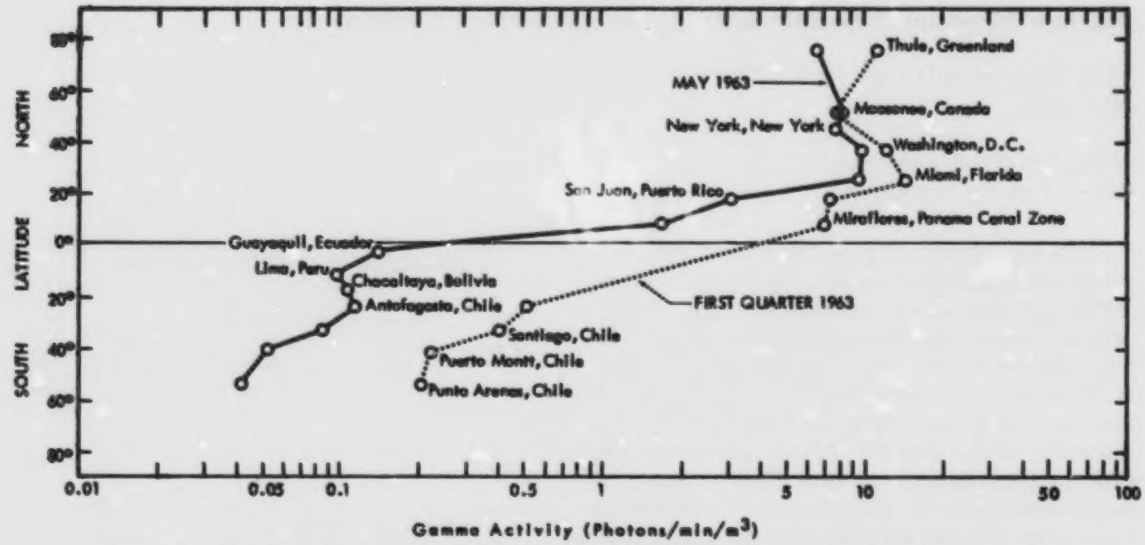

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, FIRST QUARTER AND MAY, 1963

polystyrene (Microsorban) filters. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to the Health and Safety Laboratory, New York City, for analysis. A more complete description of the sampling equipment was presented in the previous issue of *RHD* (*2*).

The 80th Meridian Network data for May 1963 is presented in table 1. Both the weekly and monthly total gamma averages are given as an indicator of fission products. The beta activity has been estimated by a method described earlier (*1*) for the purpose of comparison with 80th Meridian Network data prior to January 1, 1963 (*3*).

A comparison of the May and the first quarter 1963 average total gamma activity profiles in figure 2 indicates a relatively greater decline in the Southern Hemisphere than in the Northern. This might be attributable to a general decline which is somewhat canceled in the north by the usual spring rise (injection of accumulated fission products from the stratosphere).

It may be observed in table 1 that the gamma ratios (gamma over 1 Mev: total gamma) are in general higher than the 0.011 which would be expected for fission products more than 4 months old. The Northern Hemisphere had an average ratio of 0.024 with a standard deviation of about 0.003. The Southern Hemisphere had an average gamma ratio of 0.032; S.D., 0.015. It has been pointed out by Collins that significant concentrations of antimony-124 have been detected along the 80th Meridian (*2*). Antimony-124 is not a fission product but is formed by neutron activation. It has a half life of 60 days and emits gamma photons with energies greater than 1 Mev. It therefore seems plausible that antimony-124 and possibly other activation products have increased the values of the gamma ratios.

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(*2*) Collins, W. R., Jr.: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, March and April 1963, *Radiological Health Data*, 4:437-40, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1963).

(*3*) Naval Research Laboratory, The 80th Meridian (West) Sampling Program, December 1962, *Radiological Health Data*, 4:165-6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (April 1963).

Monthly Deposition of Various Radionuclides

For the purpose of this section, fallout is defined as the deposition of radioactive materials on the earth's surface.

Total fallout is generally considered to be composed of two fractions: that deposited by the settling of particulates, often termed dry fallout, and that contained in precipitation, sometimes called wet fallout or rainout. Normally, fallout is expressed in terms of the activity of selected radionuclides deposited on a unit surface during a given period of time.

FALLOUT IN THE UNITED STATES AND OTHER AREAS[1]

July–December 1962

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 40 sites in the United States and 93 locations in other countries. HASL data from 37 of the U.S.

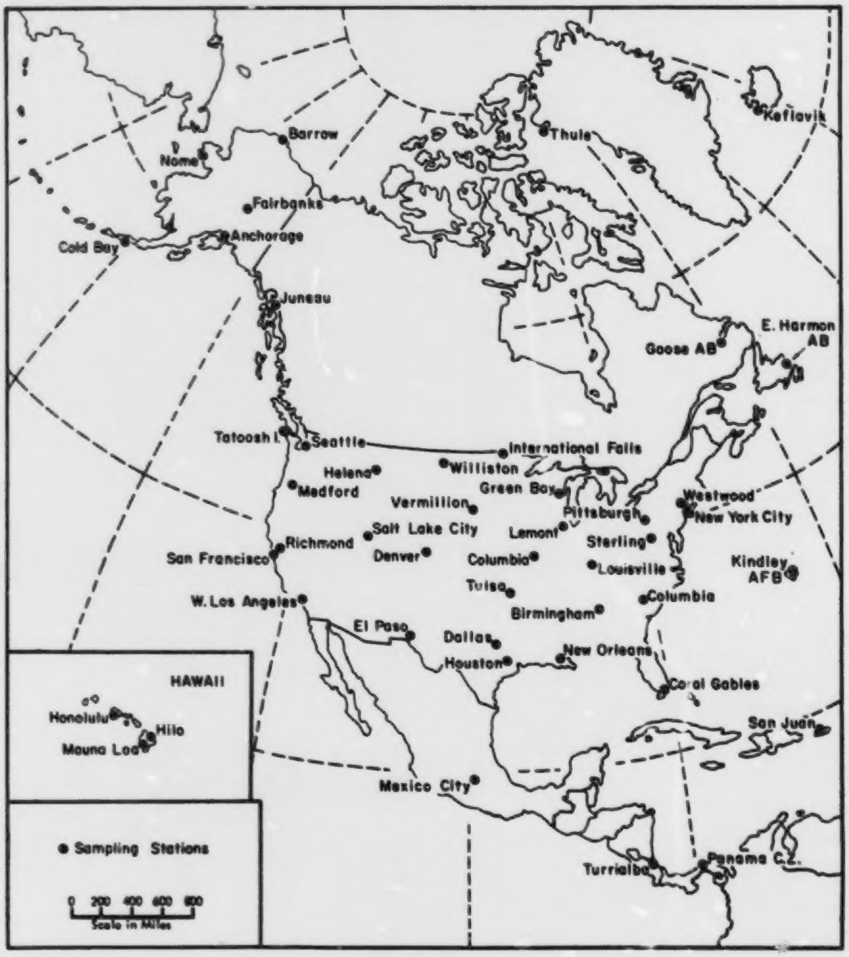
Barrow
Nome
Thule
Keflavik
Fairbanks
Anchorage
Cold Bay
Juneau
Goose AB
E. Harmon AB
Tatoosh I.
Seattle
International Falls
Helena
Williston
Medford
Green Bay
Vermillion
Pittsburgh
Westwood
New York City
Salt Lake City
Lemont
Sterling
Richmond
San Francisco
Denver
Columbia
Louisville
Kindley AFB
Tulsa
Columbia
W. Los Angeles
Birmingham
El Paso
Dallas
Houston
New Orleans
Coral Gables
HAWAII
Honolulu
Hilo
Mauna Loa
San Juan
Mexico City
Sampling Stations
0 200 400 600 800
Scale in Miles
Turrialba
Panama C.Z.

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

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[1] The data in this article were extracted from *Fallout Program Quarterly Summary Report, HASL-135*:2-144 Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (April 1, 1963).

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT—HASL, JULY—DECEMBER 1962

[Deposition in nc/m^2]

Sampling location and type of collection		July	Aug.	Sept.	Oct.	Nov.	Dec.
Ala:	Birmingham (pot)	0.52	0.56	0.30	lost	1.13	0.46
Alaska:	Anchorage (col)	0.42		0.77	0.20	0.12	0.21
	Barrow (col)	[a]—	—	0.59	0.00	—	0.00
	Cold Bay (col)	0.32	0.69	0.50	0.17	0.23	0.11
	Fairbanks (col)	0.76	0.66	0.13	0.07	0.25	0.04
	Juneau (col)	0.98	0.36	1.42	0.94	0.72	0.71
	Nome (col)	—	—	1.23	—	—	—
Calif:	W. Los Angeles (pot)	0.04	0.06	0.02	0.10	0.04	0.08
	Richmond (col)	0.04	0.05	0.06	0.41	0.12	0.39
	Richmond (pot)	0.03	0.02	0.04	0.38	0.24	0.39
	San Francisco (col)	2.03	0.02	0.24	0.20	0.07	0.21
Colo:	Denver (col)	0.34	0.31	0.11	0.15	0.10	0.04
Fla:	Coral Gables (pot)	0.50	0.37	0.47	0.51	0.15	0.15
Hawaii:	Hilo (col)	1.06	0.48	1.01	—	1.07	0.32
	Mauna Loa (col)	0.01	0.02	0.05	0.00	—	0.02
	Oahu (pot)	0.23	lost	0.35	0.18	0.03	0.50
Ill:	Lemont (pot)	0.72	0.09	0.32	0.40	0.12	0.09
Ky:	Louisville (pot)	0.40	0.33	0.21	0.66	1.07	0.46
La:	New Orleans (col)	0.44	0.22	0.22	0.12	0.07	0.44
Minn:	International Falls (col)	0.75	0.49	—	0.07	0.18	—
Mo:	Columbia (col)	0.93	0.32	0.04	0.05	0.28	0.30
Mont:	Helena (col)	1.34	1.04	0.20	0.22	0.11	0.08
N.J:	Westwood (pot)	1.01	1.33	0.48	1.20	0.96	1.14
	Westwood (col)	0.92	1.10	0.52	1.15	0.48	1.50
N.Y:	New York (pot)	0.81	0.79	0.37	0.39	0.34	0.45
N. Dak:	Williston (col)	1.43	0.17	0.13	0.29	0.27	0.07
Okla:	Tulsa (pot)	—	—	0.75	0.40		[b]0.90
Ore:	Medford (col)	0.08	0.14	0.07	0.33	0.45	0.34
Pa:	Pittsburgh (pot)	1.46	1.24	0.59	0.53	0.62	0.73
	Pittsburgh (col)	1.28	0.74	0.54	0.44	0.49	0.60
S.C:	Columbia (col)	0.72	0.32	0.49	0.02	0.07	0.32
S. Dak:	Vermillion (pot)	0.99	1.29	1.13	0.36	0.03	lost
Tex:	Dallas (col)	0.29	0.13	0.03	lost	0.63	0.69
	El Paso (col)	0.27	0.05	0.26	0.03	0.17	0.12
	Houston (col)	0.06	0.22	0.15	1.25	0.48	0.40
	Houston (pot)		[b]0.53	0.20	0.45	0.95	0.72
Va:	Sterling (col)	0.47	0.09	0.26	0.26	0.60	0.36
Utah:	Salt Lake City (pot)	0.68	0.20	0.19	0.57	0.35	0.08
Wash:	Seattle (pot)	0.22	0.47	0.72	0.29	0.86	0.74
	Tatoosh I. (col)	0.41	0.56	lost	lost	2.47	0.02
Wis:	Green Bay (col)	0.81	1.00	0.04	0.50	0.23	0.09
Greenland:	Thule (col)	0.12	0.25	0.03	0.09	0.03	0.02
Iceland:	Keflavik (col)	0.22	—	0.39	0.59	0.54	0.72
Newfoundland:	Goose A. B. (col)	1.08	0.54	—	—	0.21	0.19
	E. Harmon AB (col)	0.85	1.34	0.40	0.04	0.72	0.27
Bermuda:	Kindley AFB (col)	0.10	0.35	0.48	0.49	0.81	1.07
Puerto Rico:	San Juan (col)		[b]0.77	0.21	0.12	0.14	0.36
Mexico:	Mexico City (col)	—	0.34	0.06	0.08	0.03	0.03
Costa Rica:	Turrialba (col)	0.05	0.24	0.05	0.05	0.10	0.17
Panama Canal Zone	(col)	—	0.59	0.12	0.11	0.18	0.22

[a] Dash indicates sample or analysis not received.
[b] Two month sample.

TABLE 2.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES, 1962

Location and analyses	July	Aug.	Sept.	Oct.	Nov.	Dec.
California, Richmond						
Precipitation (mm)	dry	0.254	dry	165.9	22.9	83.8
Sr^{89}/Sr^{90} ratio	3.6	3.6	14	17	49	37
Zr^{95} (nc/m^2)	0.525	0.405	1.22	13.0	15.6	28.1
Cs^{137} (nc/m^2)	0.073	0.054	0.081	0.618	0.217	0.703
Ba^{140} (nc/m^2)	[a]—	—	—	—	—	—
New Jersey, Westwood						
Precipitation (mm)	3.28	18.9	8.76	119.4	117.1	72.4
Sr^{89}/Sr^{90} ratio	6.5	5.1	15	26	34	29
Zr^{95} (nc/m^2)	14.5	25.6	11.3	45.5	37.1	44.8
Cs^{137} (nc/m^2)	1.20	1.88	0.683	1.83	1.13	lost
Ba^{140} (nc/m^2)	—	—	—	—	—	—
Pennsylvania, Pittsburgh						
Precipitation (mm)	8.05	6.55	17.4	54.6	35.3	59.4
Sr^{89}/Sr^{90} ratio	6.0	5.0	18.5	24	43	32
Zr^{95} (nc/m^2)	16.9	21.85	25.8	35.0	35.0	30.8
Cs^{137} (nc/m^2)	2.32	low	0.961	0.834	0.950	1.11
Ba^{110} (nc/m^2)	—	—	—	—	—	—
Texas, Houston						
Precipitation (mm)		[b]7.04	10.1	79.2	144.3	120.1
Sr^{89}/Sr^{90} ratio		[b]9.9	8.0	22	79	30
Zr^{95} (nc/m^2)		[b]7.64	22.3	29.2	42.1	52.1
Cs^{137} (nc/m^2)		—	—	—	1.73	1.27
Ba^{140} (nc/m^2)		[b]12.2	1.64	—	—	—

[a] Dash indicates sample not analyzed for nuclide indicated.
[b] Two month sample.

stations and 8 other selected points in the Western Hemisphere (see figure 1) covering the period from July 1962 through December 1962 are summarized in tables 1 and 2.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout for a period of one month are collected in stainless steel pots with exposed areas of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with exposed area of 0.072m^2, attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90 and the ratio of strontium-89 to strontium-90. The strontium-90 data are given in table 1 for the 45 selected stations. Where duplicate samples were collected, the average values are given.

Other Radionuclides

Laboratories at Richmond, California; Westwood, New Jersey; Pittsburgh, Pennsylvania; and Houston, Texas, have analyzed duplicate monthly collections for various radionuclides. The monthly deposition rates for Zr^{95}, Cs^{137}, and Ba^{140}, as well as the Sr^{89}/Sr^{90} ratio and precipitation depth, are presented in table 2. The strontium-90 values for these stations are included in table 1.

REFERENCE

(*1*) Ong, L. D. Y.: Homogeneity Between Pot and Ion Exchange Column Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL-135*:256-69, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1963), price $4.00.

FALLOUT MEASUREMENTS IN CANADA
May and June 1963

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these precipitation or fallout samples for May and June 1963 are given in table 3.

Radiochemical analyses of fallout samples for five stations for the months of October 1962 through April 1963 were included with the tables of gross beta in precipitation in the February through August 1963 issues of *Radiological Health Data*.

TABLE 3.—ANALYSIS OF FALLOUT FOR SPECIFIC RADIOACTIVE ISOTOPES[a]—RFSP, MAY AND JUNE 1963

[nc/m^2]

Station	Deposition during May[b]					Deposition during June[b]				
	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}
Calgary	3.89	0.97	1.70	11.30	0.06	28.80	6.77	13.40	57	0.03
Coral Harbour	[c]—	—	—	—	—	4.22	1.03	1.36	—	—
Edmonton	7.93	2.41	4.63	—	—	14.85	4.04	2.94	—	—
Ft. Churchill	—	—	—	—	—	9.99	2.55	5.11	—	—
Ft. William	22.05	4.04	7.71	—	—	16.51	5.38	0.39	—	—
Fredericton	9.89	2.71	—	—	—	9.06	2.42	3.42	—	—
Goose Bay	7.49	1.72	2.74	—	—	19.42	4.39	4.70	—	—
Halifax	15.70	4.34	7.79	54.40	0.16	6.98	1.26	2.94	15.00	0.07
Inuvik	2.70	0.64	1.15	—	—	—	—	—	—	—
Montreal	13.80	2.68	4.41	29.10	0.12	14.30	3.20	6.59	32.40	0.12
Moosonee	13.60	3.40	6.69	—	—	—	—	—	—	—
Ottawa	4.96	1.95	3.89	—	—	10.75	2.21	9.05	—	—
Quebec	10.69	2.91	—	—	—	10.22	3.26	1.86	—	—
Regina	—	—	—	—	—	10.97	2.57	6.04	—	—
Resolute	5.86	1.65	—	—	—	7.65	1.98	1.69	—	—
St. John's, Nfld.	15.90	2.32	5.17	—	—	—	—	—	—	—
Saskatoon	9.88	1.95	2.70	—	—	17.11	3.99	7.53	—	—
Sault Ste. Marie	9.80	3.24	—	—	—	11.90	3.41	0.46	—	—
Toronto	11.18	2.37	4.53	—	—	4.87	1.16	2.13	—	—
Vancouver	2.12	0.36	0.77	6.40	0.06	3.53	0.89	1.77	11.50	0.11
Whitehorse	[d]	[d]	[d]	[d]	[d]	—	—	—	—	—
Windsor	8.26	2.38	4.59	—	—	—	—	—	—	—
Winnipeg	21.90	4.15	7.40	48.10	0.16	—	—	—	—	—
Yellowknife	2.64	0.37	0.23	—	—	10.10	2.81	3.38	—	—

[a] All values corrected for decay back to end of collection month.
[b] Values for Sr^{90}, Cs^{137} and Zr^{95} do not include the activities of their daughter isotopes, Y^{90}, Ba^{137m} and Nb^{95}.
[c] Dash indicates no analysis.
[d] No sample.

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SECTION II.—MILK AND FOOD

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
June 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

Milk surveillance for radionuclide content, as currently conducted by the Public Health Service, developed from a limited raw milk surveillance program established in 1957. Among the primary objectives of the original investigation was the development of methods for the collection and analysis of milk that would be suitable for programs of broader scope.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling network in July 1960. Forty-six stations were initially selected to provide nationwide surveillance of milk production and consumption areas.

As further needs developed, more milk sampling points were added through July 1962, when the total number of stations reached was 62. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, or Northeastern Radiological Health laboratories for analysis. Approximately 3–6 days after sample collection, any results from the gamma analyses which indicate concentrations of iodine-131 greater than 100 pc/liter are made available to States for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a week at nearly all stations and daily

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TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, JUNE 1963

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month
Ala:	Montgomery	1.21	1.20	100	75	23	22	<10	<10	80	85	10	<10
Alaska:	Palmer	1.17	1.14	35	65	15	22	<10	<10	55	70	<10	<10
Ariz:	Phoenix	1.16	1.13	20	10	5	5	<10	<10	15	10	<10	<10
Ark:	Little Rock	1.19	1.16	200	180	51	52	<10	<10	195	225	20	<10
Calif:	Sacramento	1.21	1.18	115	70	19	11	<10	<10	90	100	<10	<10
	San Francisco	1.22	1.20	175	80	27	19	<10	<10	110	90	<10	<10
Colo:	Denver	1.23	1.22	35	70	14	22	<10	<10	70	105	<10	<10
Conn:	Hartford	1.09	1.10	30	60	22	36	<10	<10	120	190	<10	<10
Del:	Wilmington	1.07	1.14	65	95	28	41	<10	<10	130	195	<10	<10
D.C:	Washington	1.16	1.13	90	100	24	27	<11	<10	120	160	<10	<10
Fla:	Tampa	1.18	1.17	40	35	13	12	<10	<10	200	215	10	<10
Ga:	Atlanta	1.21	1.19	145	120	33	32	<10	<10	155	155	10	<10
Hawaii:	Honolulu	1.15	1.13	60	45	10	10	<10	<10	65	85	<10	<10
Idaho:	Idaho Falls	1.20	1.17	80	170	22	39	<10	<10	110	165	<10	<10
Ill:	Chicago	1.06	1.08	30	60	21	29	<10	<10	95	135	<10	<10
Ind:	Indianapolis	1.10	1.14	55	60	29	33	<10	<10	100	125	<10	<10
Iowa:	Des Moines	1.19	1.15	145	180	31	33	<10	<10	95	120	<10	<10
Kans:	Wichita	1.19	1.14	90	175	21	30	<10	<10	85	145	<10	<10
Ky:	Louisville	1.18	1.16	180	220	37	46	<10	<10	125	190	10	<10
La:	New Orleans	1.23	1.19	175	140	45	42	10	<10	170	170	20	<10
Maine:	Portland	1.07	1.11	30	60	25	34	<10	<10	120	140	<10	<10
Md:	Baltimore	1.15	1.15	105	145	24	30	<10	<10	140	215	10	<10
Mass:	Boston	1.10	1.15	35	70	28	43	<10	<10	150	235	<10	<10
Mich:	Detroit	1.08	1.12	25	45	20	28	<10	<10	85	115	<10	<10
	Grand Rapids	1.11	1.17	25	40	19	30	<10	<10	90	115	<10	<10
Minn:	Minneapolis	1.20	1.20	80	180	28	45	<10	<10	130	190	<10	<10
Miss:	Jackson	1.25	1.20	180	120	38	32	<10	<10	120	110	20	<10
Mo:	Kansas City	1.21	1.16	155	240	32	39	<10	<10	100	145	<10	<10
	St. Louis	1.19	1.18	110	160	27	38	<10	<10	95	130	<10	<10
Mont:	Helena	1.19	1.14	70	120	21	29	<10	<10	105	135	<10	<10
Nebr:	Omaha	1.21	1.24	100	155	27	35	<10	<10	90	120	<11	<10
Nev:	Las Vegas	1.15	1.15	25	30	7	7	<10	<10	50	60	<10	<10
N.H:	Manchester	1.12	1.18	40	75	28	43	<10	<10	170	270	<10	<10
N.J:	Trenton	1.09	1.15	40	65	26	33	<10	<10	110	170	<10	<10
N. Mex:	Albuquerque	1.16	1.13	40	55	10	13	<10	<10	35	50	<10	<10
N.Y:	Buffalo	1.06	1.10	30	65	22	32	<10	<10	105	150	<10	<10
	New York	1.09	1.09	40	85	24	38	<10	<10	110	185	<10	<10
	Syracuse	1.08	1.12	35	75	24	37	<10	<10	105	170	<10	<10
N.C:	Charlotte	1.25	1.19	135	155	34	41	<10	<10	130	190	10	<10
N. Dak:	Minot	1.13	1.08	180	320	48	62	<10	<10	115	175	<10	<10
Ohio:	Cincinnati	1.09	1.16	75	85	31	39	<10	<10	90	120	<10	<10
	Cleveland	1.13	1.19	49	70	24	33	<10	<10	100	155	<10	<10
Okla:	Oklahoma City	1.17	1.14	130	135	28	31	<10	<10	120	155	10	<10
Ore:	Portland	1.24	1.22	150	165	38	36	<10	<10	160	190	<10	<10
Pa:	Philadelphia	1.08	1.13	55	75	29	39	<10	<10	130	185	<10	<10
	Pittsburgh	1.10	1.17	55	105	27	45	<10	<10	125	200	<10	<10
P.R:	San Juan	1.16	1.14	105	70	18	14	<10	<10	125	130	10	<10
R. I:	Providence	1.08	1.13	45	70	27	38	<10	<10	125	180	<10	<10
S. C:	Charleston	1.21	1.16	100	90	29	28	<10	<10	120	150	10	<10
S. Dak:	Rapid City	0.92	0.91	105	190	34	59	<10	<10	125	225	<10	<10
Tenn:	Chattanooga	1.22	1.21	195	180	40	44	<10	<10	160	210	10	<10
	Memphis	1.22	1.20	160	155	38	39	<10	<10	110	150	10	<10
Tex:	Austin	1.14	1.11	50	40	10	10	<10	<10	50	65	<10	<10
	Dallas	1.16	1.15	120	95	25	23	<10	<10	100	115	10	<10
Utah:	Salt Lake City	1.22	1.18	45	90	20	28	<10	10	110	160	<10	<10
Vt:	Burlington	1.09	1.12	30	55	24	34	<10	<10	110	145	<10	<10
Va:	Norfolk	1.17	1.16	95	100	25	27	<10	<10	120	145	10	<10
Wash:	Seattle	1.19	1.16	125	115	26	26	<10	<10	150	165	<10	<10
	Spokane	1.26	1.22	105	130	27	30	<10	<10	125	140	<10	<10
W. Va:	Charleston	1.17	1.14	145	160	37	43	<10	<10	115	155	10	<10
Wis:	Milwaukee	1.10	1.15	30	50	20	27	<10	<10	90	125	<10	<10
Wyo:	Laramie	1.20	1.17	70	115	24	37	<10	<10	120	150	<10	<10
Network average		1.16	1.15	87	106	25.9	32.0	<10	<10	112	149	<10	<10

for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week. After gamma scanning, samples for two weeks are composited and analyzed for strontium-89, strontium-90 and calcium.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Sampling frequency and schedules of analyses are adjusted to meet changing conditions.

Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation

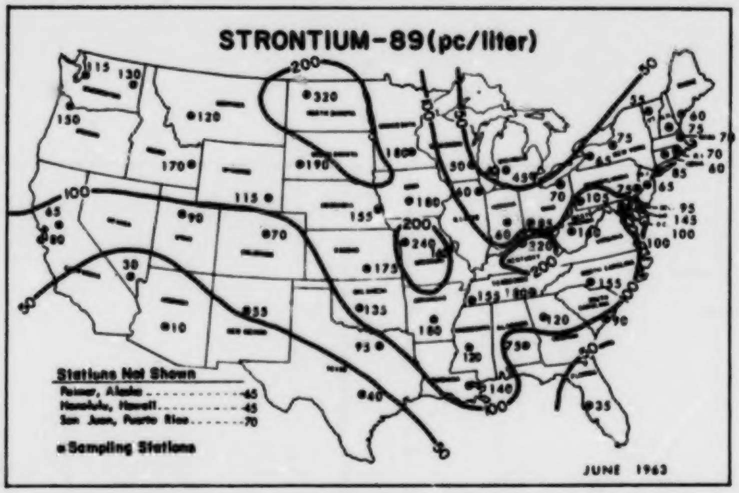
STRONTIUM-89(pc/liter)
Stations Not Shown
Palmer, Alaska 45
Honolulu, Hawaii 45
San Juan, Puerto Rico 70
• Sampling Stations
JUNE 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1963

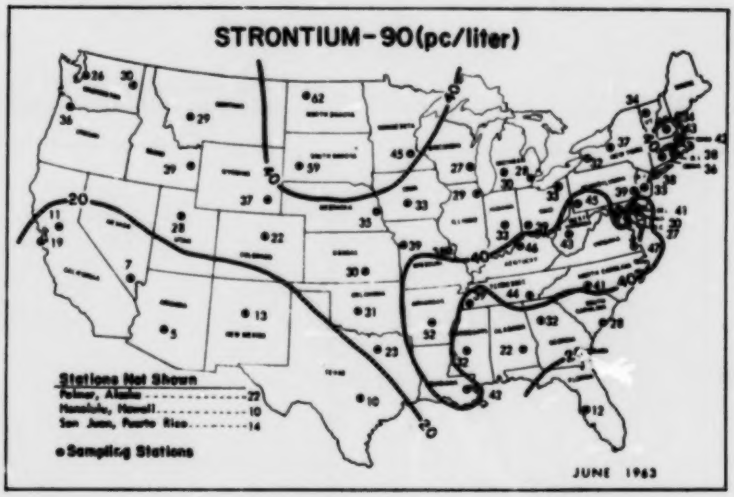
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 22
Honolulu, Hawaii 10
San Juan, Puerto Rico 14
• Sampling Stations
JUNE 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1963

spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as that concentration at which the statistical two-standard-deviation analytical error is 100 percent of the measured concentration (*1*). Accordingly the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

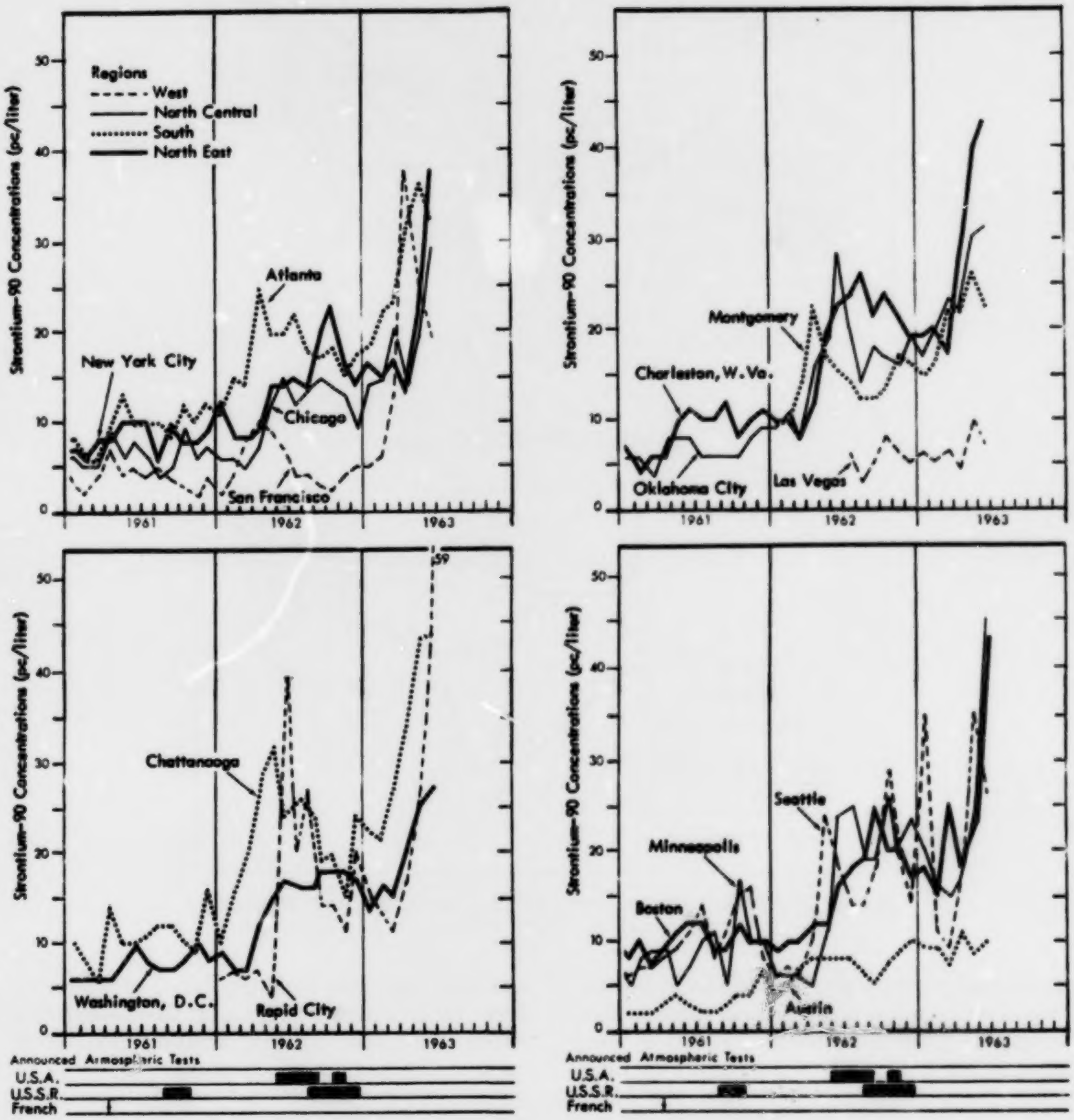

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, JUNE 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5-20	1	<1-9	2	<10	62	<5-45	1	<10	62
25-45	6	10-19	7			50-95	7		
50-70	16	20-29	13			100-145	21		
75-95	11	30-39	27			150-195	25		
100-120	8	40-49	10			200-245	7		
125-145	4	50-59	2			250-295	1		
150-170	7	60-69	1						
175-195	6								
> 195	3								

Data Presentation

Table 1 presents summaries of the analyses for June 1963 (May 26-June 29, 1963). When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.2 to 1.8 grams/liter. In June, for example, 1, 14, 14, 15, and 18 stations reported their respective monthly average potassium concentrations as 1.2, 1.3, 1.4, 1.5, and 1.6 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. Table 2 shows the distribution of the network's stations according to radionuclide concentrations in milk, using the monthly average data shown in table 1.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of RHD, the average monthly strontium-90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented (see figure 3). Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits the graphical presentation of data for each city in the network at least twice a year.

REFERENCE

(*1*) Division of Radiological Health, Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291-6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963)

INDIANA MILK NETWORK
June 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4):

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-140 are conducted on a weekly basis except when iodine-131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

An ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The State average is an arithmetic average of the station values.

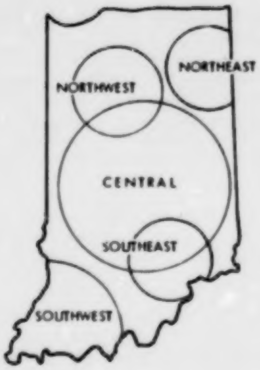

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, JUNE 1963

[Concentrations in pc/liter]

Sampling location	Strontium -89	Strontium -90	Iodine -131	Cesium -137	Barium -140
Northeast	<10	49	<10	145	<10
Southeast	<10	61	<10	180	<10
Central	20	48	<10	120	<10
Southwest	20	89	<10	110	<10
Northwest	35	60	<10	155	<10
State average	15	54	<10	140	<10

REFERENCE

(*1*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry* *33*:1306–8 (September 1961).

NEW YORK NETWORK
May 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 5), are analyzed for radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131 and cesium-137 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed for iodine-131 daily. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from

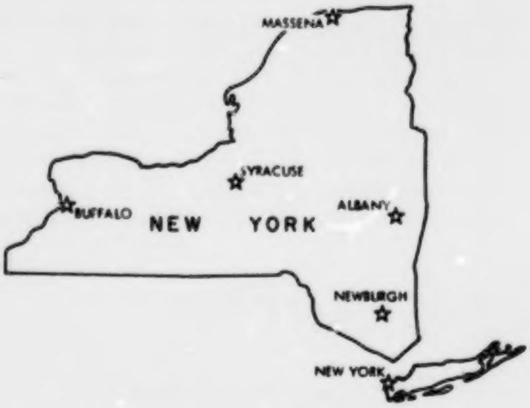

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 4.—RADIONUCLIDES IN NEW YORK MILK, MAY 1963

[Concentrations in pc/liter]

Sampling location	Strontium -89	Strontium -90	Iodine -131	Cesium -137
Albany	47	12	<20	61
Buffalo	59	22	<20	74
Massena	36	12	<20	79
Newburgh	88	20	<20	74
New York City	87	19	20	75
Syracuse	70	15	<20	80

the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 4.

REFERENCE

(1) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999-R-2*, (March 1963). Single copies available on request from Public Inquiries Branch, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

CANADIAN MILK NETWORK[1]
May—June 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department analyzed milk powders from November 1955 through December 1962, but liquid whole milk had been monitored since April 1962 for iodine-131 only.

With this change, it has been possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. This permits the observation of a number of environmental variables which may effect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

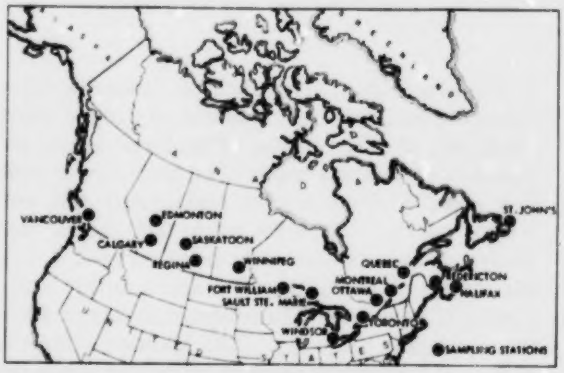

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS, JUNE 1963

TABLE 5.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MAY 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.21	18.7	32.6	2	92
Edmonton	1.17	61.4	27.1	1	117
Ft. William	1.13	25.5	30.9	2	141
Fredericton	1.16	9.2	32.1	1	178
Halifax	1.15	7.3	27.9	0	156
Montreal	1.10	5.4	27.5	4	78
Ottawa	1.10	8.3	16.5	2	68
Quebec	1.08	12.7	20.4	1	140
Regina	1.07	11.8	18.8	1	92
St. John's, Nfld	1.08	7.6	25.4	2	91
Saskatoon	1.09	42.2	32.0	1	83
Sault Ste. Marie	1.04	17.5	22.4	2	100
Toronto	1.09	14.2	14.2	1	83
Vancouver	1.23	38.5	37.9	4	219
Windsor	1.14	10.1	14.8	2	58
Winnipeg	1.13	6.7	11.6	0	96
Average	1.13	18.6	24.5	2	112

TABLE 6.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JUNE 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.30	146.8	52.2	3	199
Edmonton	1.28	145.7	49.0	2	211
Ft. William	1.34	241.4	83.2	2	364
Fredericton	1.36	48.9	31.8	1	154
Halifax	1.36	98.2	54.1	1	208
Montreal	1.31	101.1	38.6	1	179
Ottawa	1.32	83.3	26.5	2	153
Quebec	1.26	82.1	35.3	3	176
Regina	1.30	210.5	65.8	4	192
St. John's, Nfld	1.34	116.1	67.3	2	248
Saskatoon	1.27	109.6	39.4	3	127
Sault Ste. Marie	1.28	134.8	51.3	2	236
Toronto	1.32	39.9	19.9	4	84
Vancouver	1.28	69.8	39.5	5	221
Windsor	1.34	68.5	20.4	1	94
Winnipeg	1.26	129.9	48.6	0	138
Average	1.31	114.2	45.2	2	187

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1, 2*). Table 5 and 6 present the results of the measurements of strontium-89, strontium-90, cesium-137, and iodine-131 in Canadian liquid whole milk for May and June, respectively. Figures

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[1] Data from *Radiation Protection Programs*, Vol. 1, No. 7, Radiation Protection Division, Canadian Department of National Health and Welfare.

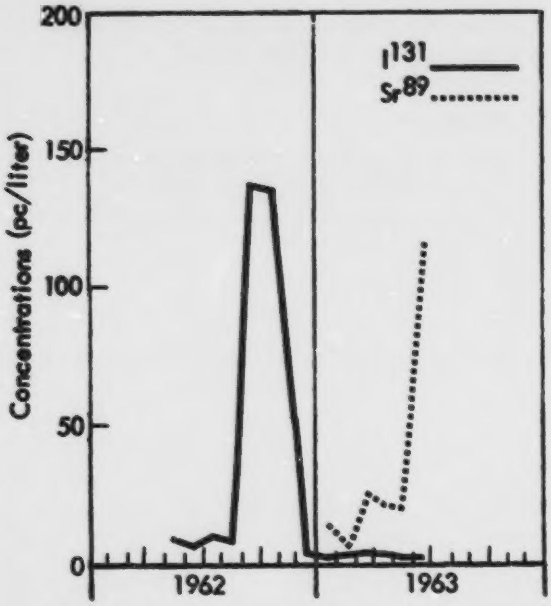

FIGURE 7.—IODINE-131 AND STRONTIUM-89 CONCENTRATIONS IN WHOLE MILK

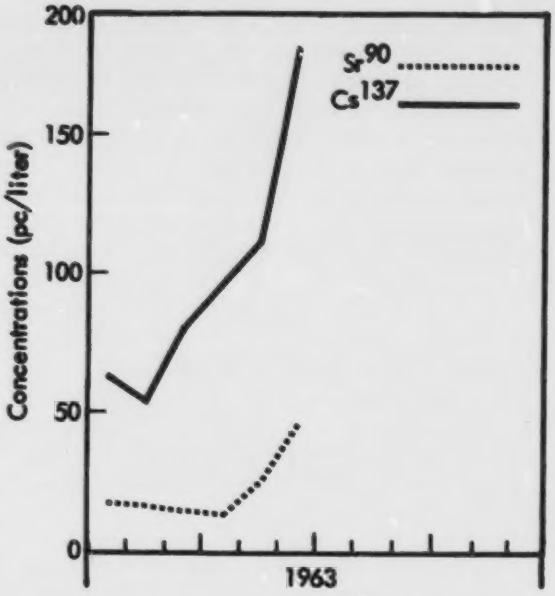

FIGURE 8.—STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN WHOLE MILK

7 and 8 show the time profiles of these radionuclides in milk.

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

RADIOSTRONTIUM IN MILK (*1*)
October 1962–March 1963

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory (HASL) began monitoring liquid whole milk in New York City in 1954 for strontium-90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, and at Mandan, North Dakota. Liquid whole milk monitoring was started in Honolulu, Hawaii in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu sample is a monthly composite of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used for cattle feed, while the Perry sample is powdered milk used for human consumption. The Honolulu data are of interest since the cows there are on pasture throughout the year.

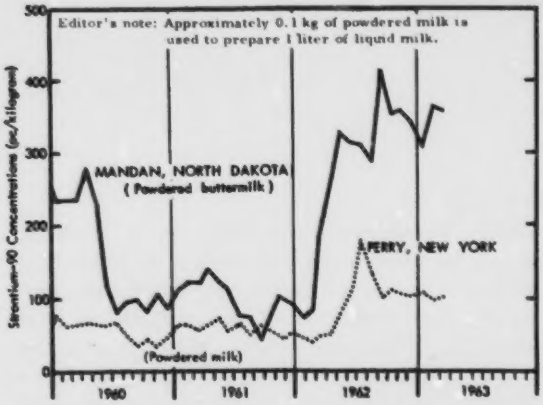

FIGURE 9.—STRONTIUM-90 IN POWDERED MILK SAMPLES

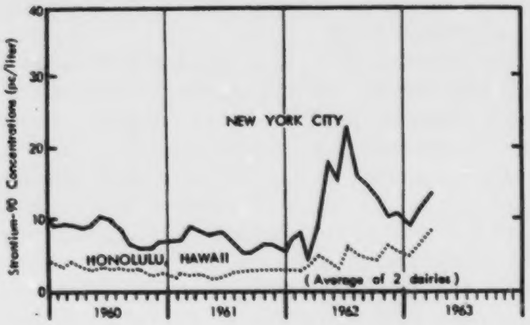

FIGURE 10.—STRONTIUM-90 IN LIQUID MILK SAMPLES

Strontium-89, which has a half life of about 50 days, is indicative of fresh fission products from atmospheric nuclear testing being deposited. Because of the low strontium-89 levels since January 1963, analyses for this nuclide were discontinued. The Sr^{89}/Sr^{90} ratios are presented in tables 7 and 8, as are the calcium and strontium data. The fluctuations of strontium-90 with time are shown in figures 9 and 10.

[*The values ascribed to New York City for June 1962 shown in table 4 on page 29 of the January 1963 issue of RHD are in error. Through reanalyses of the sample, the following values for liquid milk from New York City for June 1963 have been ascertained: 1.04 g Ca/liter; 15.1 pc Sr^{90}/liter, 14.5 pc Sr^{90}/g Ca, Sr^{89}/Sr^{90} ratio = 8.*]

TABLE 7.—RADIOSTRONTIUM AND CALCIUM IN LIQUID MILK, OCTOBER 1962–MARCH 1963

Sampling station and period	Calcium (g/liter)	Strontium -90 (pc/liter)	Strontium -90 (pc/g Ca)	Ratio[1] (Sr^{89}/Sr^{90})
New York, New York				
1962 Oct	0.92	12.6	13.6	6
Nov	0.96	10.0	10.4	3
Dec	0.97	10.6	10.9	1
1963 Jan	0.97	8.1	8.3	2
Feb	1.01	11.3	11.2	—
Mar	1.03	13.8	13.4	—
Honolulu, Hawaii				
1962 Oct	1.02	4.5	4.4	3
Nov	1.19	6.1	5.1	3
Dec	1.04	5.6	5.6	5
1963 Jan	1.07	5.1	4.8	7
Feb	1.18	6.1	5.7	—
Mar	1.10	8.4	7.7	—

[1] Strontium-89 value extrapolated to the midpoint of sampling period.

TABLE 8.—RADIOSTRONTIUM AND CALCIUM IN POWDERED MILK AND BUTTERMILK, OCTOBER 1962—MARCH 1963

Sampling station and period	Calcium (g/kg)	Strontium -90 (pc/kg)	Strontium -90 (pc/g Ca)	Ratio[1] (Sr^{89}/Sr^{90})
Powdered Milk				
Perry, New York				
1962 Oct	8.3	115	13.6	6
Nov	8.5	109	12.8	3
Dec	8.7	107	12.3	1
1963 Jan	8.8	109	12.5	<1
Feb	8.6	98	11.4	—
Mar	8.8	105	11.9	—
Powdered Buttermilk				
Mandan, North Dakota				
1962 Oct	11.3	356	31.5	6
Nov	12.5	360	28.8	5
Dec	11.1	347	31.1	3
1963 Jan	11.6	306	26.6	1
Feb	11.6	363	31.3	—
Mar	12.0	360	30.0	—

[1] Strontium-89 value extrapolated to the midpoint of sampling period.

Comment

The Honolulu milk samples still contain less strontium-90 per liter than those of other sampling stations. The strontium-90 concentration in milk at all stations decreased during the fourth quarter 1962, reaching a low during mid winter. However, levels began rising as spring approached.

REFERENCES

(1) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-138*:154–62, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1963), price $3.50.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
May–July 1961	March 1962
August–December 1961	June 1962
January–February 1962	September 1962
March–June 1962	January 1963
July–September 1962	April 1963

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: August 1962–July 1963
Strontium-89 and Strontium-90: July 1962–June 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in picocuries per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. The columns (B and C) of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. Column D shows this new 12-month index value. In addition, the second column in table 1 gives the average iodine-131 concentrations for July 1963.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks ending in a given month. Procedures examplified by (a) and (b) above tend to minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. Column (A) gives the twelve-month index values for the period indicated. Columns (B) and (C) show the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons, it is desirable to use a standard quantity of milk in the development of index values for the different radionuclides. When one is concerned with radiostrontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the daily intake guidance for radiostrontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18-month group is not more than 1 liter per day (*4, 5*). Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*. Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1962).

(*4*) U.S. Department of Agriculture: *Food, The Yearbook of Agriculture*, 1959, pp. 382–95, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (1959), price $2.25.

(*5*) Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962, *Radiological Health Data*, *4*:124–9, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (March 1963).

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[pc day/liter]

Sampling locations		July 1963 iodine-131 averages (pc/liter)	Iodine-131 index values[a]			
			July 1962–June 1963 (A)	July 1–July 28, 1962 (B)	June 30–July 27, 1963 (C)	August 1962–July 1963 (D)
Ala:	Montgomery	<10	6,170	280	140	6,030
Alaska:	Palmer	<10	37,180	280	140	37,040
Ariz:	Phoenix	<10	3,930	560	140	3,510
Ark:	Little Rock	<10	13,900	280	140	13,760
Calif:	Sacramento	<10	4,460	560	140	4,040
	San Francisco	<10	4,630	840	140	3,930
Colo:	Denver	<10	6,100	1,400	140	4,840
Conn:	Hartford	<10	7,500	280	140	7,360
Del:	Wilmington	<10	11,350	280	140	11,210
D.C:	Washington	<10	8,270	140	140	8,270
Fla:	Tampa	<10	6,490	140	140	6,490
Ga:	Atlanta	<10	8,900	560	140	8,480
Hawaii:	Honolulu	<10	4,420	280	140	4,280
Idaho:	Idaho Falls	<10	8,200	1,400	140	6,940
Ill:	Chicago	<10	11,840	1,120	140	10,860
Ind:	Indianapolis	<10	11,000	560	140	10,580
Iowa:	Des Moines	<10	17,020	1,400	140	15,760
Kans:	Wichita	<10	11,350	1,680	140	9,810
Ky:	Louisville	<10	9,600	140	140	9,600
La:	New Orleans	<10	10,020	280	140	9,880
Maine:	Portland	<10	7,990	280	140	7,850
Md:	Baltimore	<10	8,270	140	140	8,270
Mass:	Boston	<10	7,780	140	140	7,780
Mich:	Detroit	<10	12,680	560	140	12,260
	Grand Rapids	<10	9,560	560	140	9,140
Minn:	Minneapolis	<10	11,560	840	140	10,860
Miss:	Jackson	<10	9,530	560	140	9,110
Mo:	Kansas City	<10	16,390	1,680	140	14,850
	St. Louis	<10	9,740	1,120	140	8,760
Mont:	Helena	<10	13,100	840	140	12,400
Nebr:	Omaha	<10	15,900	1,960	140	14,080
Nev:	Las Vegas	<10	5,080	1,680	140	3,510
N.H:	Manchester	<10	7,710	280	140	7,570
N.J:	Trenton	<10	7,990	280	140	7,850
N. Mex:	Albuquerque	<10	5,960	1,120	140	4,980
N.Y:	Buffalo	<10	8,550	560	140	8,130
	New York	<10	11,070	280	140	10,930
	Syracuse	<10	9,210	560	140	8,790
N.C:	Charlotte	<10	3,200	140	140	3,200
N. Dak:	Minot	<10	13,970	1,400	140	12,710
Ohio:	Cincinnati	<10	13,660	840	140	12,960
	Cleveland	<10	10,930	280	140	10,790
Okla:	Oklahoma City	<10	12,540	560	140	12,120
Ore:	Portland	<10	8,900	840	140	8,200
Pa:	Philadelphia	<10	10,650	560	140	10,230
	Pittsburgh	<10	13,940	560	140	13,520
P.R:	San Juan[b]	<10	5,190	140	140	5,190
R.I:	Providence	<10	7,990	140	140	7,990
S.C:	Charleston	<10	7,180	560	140	6,760
S. Dak:	Rapid City	<10	14,150	1,400	140	12,890
Tenn:	Chattanooga	<10	7,430	140	140	7,430
	Memphis	<10	9,880	280	140	9,740
Tex:	Austin	<10	11,040	140	140	11,040
	Dallas	<10	17,690	140	140	17,690
Utah:	Salt Lake City	<10	31,920	16,240	140	15,820
Vt:	Burlington	<10	8,380	280	140	8,240
Va:	Norfolk	<10	6,100	140	140	6,100
Wash:	Seattle	<10	9,600	1,400	140	8,340
	Spokane	<10	9,320	2,240	140	7,220
W. Va:	Charleston	<10	6,030	280	140	5,890
Wis:	Milwaukee	<10	13,800	840	140	13,100
Wyo:	Laramie	<10	18,600	10,360	140	8,380

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(pc day/liter) (liter/day/person) (pc/person)

[b] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

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TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values[a] (pc day/liter)				Strontium-90 index values[a] (pc day/liter)			
		June 1962–May 1963 (A)	June 1962 (B)	May 26, 1963–June 29, 1963 (C)	July 1962–June 1963 (D)	June 1962–May 1963 (A)	June 1962 (B)	May 26, 1963–June 29, 1963 (C)	July 1962–June 1963 (D)
Ala:	Montgomery	22,785	1,925	2,625	23,485	6,090	560	770	6,800
Alaska:	Palmer	19,705	2,100	2,275	19,880	4,375	455	770	4,690
Ariz:	Phoenix	6,985	175	350	7,160	1,379	105	175	1,449
Ark:	Little Rock	45,885	4,200	6,300	47,985	12,355	1,120	1,820	13,055
Calif:	Sacramento	13,180	700	2,450	14,930	2,436	175	385	2,646
	San Francisco	24,325	875	2,800	26,250	3,444	245	665	3,864
Colo:	Denver	11,200	2,100	2,450	11,550	4,291	455	770	4,606
Conn:	Hartford	8,630	1,225	2,100	9,505	4,494	490	1,260	5,264
Del:	Wilmington	12,655	1,400	3,325	14,580	5,901	595	1,435	6,741
D.C:	Washington	15,400	2,275	3,500	16,625	6,321	595	945	6,671
Fla:	Tampa	12,530	875	1,225	12,880	4,277	385	420	4,312
Ga:	Atlanta	29,540	2,450	4,200	31,290	7,735	700	1,120	8,155
Hawaii:	Honolulu	12,565	875	1,575	13,265	2,394	175	350	2,569
Idaho:	Idaho Falls	10,815	1,750	5,950	15,015	4,847	455	1,365	5,257
Ill:	Chicago	10,870	2,450	2,100	10,520	5,285	525	1,015	5,775
Ind:	Indianapolis	14,490	2,100	2,100	14,490	6,090	560	1,155	6,685
Iowa:	Des Moines	28,350	5,950	6,300	28,700	6,342	910	1,155	6,587
Kans:	Wichita	17,570	2,800	6,125	20,895	4,907	560	1,050	5,397
Ky:	Louisville	31,780	4,200	7,700	35,280	8,568	875	1,610	9,303
La:	New Orleans	54,040	5,075	4,900	53,865	12,278	1,330	1,470	12,418
Maine:	Portland	11,080	1,575	2,100	11,605	6,384	455	1,190	7,119
Md:	Baltimore	14,525	2,100	5,075	17,500	6,188	595	1,050	6,643
Mass:	Boston	11,850	1,575	2,450	12,725	7,105	560	1,505	8,050
Mich:	Detroit	9,855	1,400	1,575	10,030	5,425	490	980	5,915
	Grand Rapids	8,770	1,400	1,400	8,770	4,445	420	1,050	5,075
Minn:	Minneapolis	20,860	4,025	6,300	23,135	7,483	840	1,575	8,218
Miss:	Jackson	53,305	4,900	4,200	52,605	9,884	1,015	1,120	9,989
Mo:	Kansas City	32,830	7,525	8,400	33,705	6,615	875	1,365	7,105
	St. Louis	20,790	4,025	5,600	22,365	5,677	805	1,330	6,202
Mont:	Helena	17,955	2,625	4,200	19,530	5,544	560	1,015	5,999
Nebr:	Omaha	23,520	4,550	5,425	24,395	6,268	840	1,225	6,653
Nev:	Las Vegas[b]	6,895	[c]—	1,050	7,945	1,876	[c]—	245	2,121
N.H:	Manchester	11,185	1,225	2,625	12,585	6,377	420	1,505	7,462
N.J:	Trenton	10,135	1,225	2,275	11,185	5,096	420	1,155	5,831
N. Mex:	Albuquerque	7,775	700	1,925	9,000	2,002	210	455	2,247
N.Y:	Buffalo	9,400	1,400	2,275	10,275	5,390	455	1,120	6,055
	New York	10,765	1,400	2,975	12,340	5,887	490	1,330	6,727
	Syracuse	9,680	1,050	2,625	11,255	5,040	420	1,295	5,915
N.C:	Charlotte	22,260	3,150	5,425	24,535	8,379	945	1,575	9,009
N. Dak:	Minot	21,850	4,200	11,200	28,850	9,842	1,050	2,170	10,962
Ohio:	Cincinnati	17,605	2,450	2,975	18,130	6,447	665	1,365	7,147
	Cleveland	10,800	2,100	2,450	11,150	5,313	490	1,155	5,978
Okla:	Oklahoma City	28,560	4,725	4,725	28,560	7,483	1,015	1,085	7,553
Ore:	Portland	36,050	2,275	5,250	39,025	6,405	490	1,260	7,175
Pa:	Philadelphia	11,395	1,400	2,625	12,620	5,866	455	1,365	6,776
	Pittsburgh	12,760	1,925	3,675	14,510	6,587	595	1,575	7,567
P.R.	San Juan[d]	28,455	1,925	2,450	28,980	4,298	455	490	4,333
R.I:	Providence	10,450	1,225	2,450	11,675	5,719	455	1,330	6,594
S.C:	Charleston	24,425	2,100	3,150	25,475	8,099	700	980	8,379
S. Dak:	Rapid City	24,395	6,475	6,650	24,570	7,007	1,400	2,065	7,672
Tenn:	Chattanooga	36,785	3,675	6,300	39,410	9,030	840	1,540	9,730
	Memphis	35,665	4,025	5,425	37,065	8,883	910	1,365	9,338
Tex:	Austin	13,265	1,050	1,400	13,615	2,898	280	350	2,968
	Dallas	32,725	2,975	3,325	33,075	6,622	630	805	6,797
Utah:	Salt Lake City	12,005	1,400	3,150	13,755	4,501	490	980	4,991
Vt:	Burlington	11,465	1,050	1,925	12,340	5,432	455	1,190	6,167
Va:	Norfolk	19,320	2,450	3,500	20,370	7,413	735	945	7,623
Wash:	Seattle	25,305	2,275	4,025	27,055	6,272	665	910	6,517
	Spokane	16,800	2,975	4,550	18,375	5,817	630	1,050	6,237
W. Va:	Charleston	25,515	4,025	5,600	27,090	8,456	805	1,505	9,156
Wis:	Milwaukee	9,435	1,225	1,750	9,960	4,109	385	945	4,669
Wyo:	Laramie	21,980	2,100	4,025	23,905	4,991	525	1,295	5,761

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 and strontium-90 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{89} or Sr^{90} index × milk consumption factor = 12-month Sr^{89} or Sr^{90} intake
(pc day/liter) (liter/day/person) (pc/person)

[b] Station included in Pasteurized Milk Network in July 1962. The sums in columns A and D are therefore for 11 and 12 months respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

Summary of Results from the Raw Milk Sampling Program
June 1957–April 1963

Jeptha E. Campbell and Gopala K. Murthy[1]

This report contributes to the development of environmental exposure estimates by summarizing the data on radionculides in raw milk obtained at monthly intervals, since early 1957, from selected groups of dairy farms in different areas of the U.S.A. (*1*). On the basis of the early results from this study, the Public Health Service established a comprehensive pasteurized milk network which now serves as the major source of information on radioactivity in market milk. However, the original sampling program has also been maintained, and the accumulated data now represent a sequence of observations that reflect the changing levels of specific radionuclides entering milk from fallout over the last five-year period.

Milk was chosen as the first item of the diet to be surveyed for several reasons, including (a) evidence indicating that milk and milk products were major contributors of Sr^{90} to the total diet, (b) milk is used extensively by almost all segments of the population, especially children, (c) it is produced on a year-round basis in almost every area of the United States, and (d) the relatively uniform composition of this food makes one set of methods equally applicable to all samples.

Using methods of analysis available at the time, preliminary examination of several market milk supplies showed that Cs^{137}, I^{131}, Sr^{89}, Sr^{90}, and Ba^{140} were present in measureable concentrations and led to the decision that concentrations of all of these should be rountinely determined. With this in mind, a system for the measurement of Sr^{89}, Sr^{90}, Ba^{140}, and Cs^{137} by chemical methods (*2*, *3*) and, subsequently, a technique for measurement of I^{131}, Ba^{140}, and Cs^{137} by gamma spectroscopy (*4*) were developed, which were suitable for well trained non-professional personnel and which were applicable to large numbers of samples. A technique was also developed by which milk could be satisfactorily transported without refrigeration from distant locations to a central laboratory for analysis.

The following criteria were used to select stations in discrete geographical areas within specified milksheds serving large urban populations in different regions of the United States: (a) The milk represented in each sample was from a group of farms milking a total of at least 1000 cows; (b) the number of individual farms was small enough so that collection of collateral farm data from each farm was feasible; (c) the milk samples were from a supply that was part of a metropolitan milkshed; (d) the conditions under which the milk was received were such that each sample was representative of the same farms in the production area.

At the time when these studies were begun, practically no information was available to guide the establishment of a radiation surveillance network for milk, and many of the basic decisions related to sampling procedures and analytical methods were made on the basis of intuition and judgement. One such decision was that the monthly milk samples should represent 1 or 2 days of production around the time of sampling rather than a composite of all the milk produced from one sampling period to the next.

Since these samples represented only 1 or 2 per cent of the market milk supply, it was clear that such data could not be assumed to represent all of the milk in that area. This limitation led ultimately to the establishment of an expanded surveillance network of 62 stations by the Public Health Service for measuring the levels of radioactivity in samples of pasteurized milk consumed by the public. Each sample from the latter is composited in proportion to the plant sales and reflects 80 to 100 per cent of the milk processed in each city. The results of the pasteurized milk network have been published in *Radiological Health Data* (*5*).

During the first year of operation of the raw milk network, five areas were selected for surveillance: New York, Cincinnati, St. Louis, Salt Lake City, and Sacramento. In the second year stations were added at Atlanta, Chicago, Fargo-Moorhead, Austin, and Spokane. Regular monthly samples have been received from all stations since initiation of the network except for Fargo-Moorhead which discontinued participation in January 1960.

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Methods

The method initially instituted for collecting and shipping the samples has been continued without change. One-gallon raw milk samples are taken monthly from collecting stations in each area under surveillance, preserved with 4 ml of 40% formaldehyde solution, and forwarded to the Robert A. Taft Sanitary Engineering Center for radionculide analysis. Each sample, collected in a manner to meet the criteria previously outlined, is representative of milk lots ranging from 2,000 to 90,000 gallons for the total milk supply of the designated area. In addition, during October–November 1961, daily milk samples were collected from all the nine milksheds. The frequent sampling procedure, on an every-other-day basis, was extended to the Cincinnati area until December 1962.

The concentrations of I^{131}, Ba^{140}, and Cs^{137} are measured by gamma spectroscopy (*4*) while total radioactive strontium and Sr^{90} are determined following radiochemical separation (*5, 6, 7*). The amount of Sr^{90} is computed by determining the concentration of Y^{90} in the chemically isolated strontium after a two-week period, at which time the Y^{90} and Sr^{90} are in secular equilibrium. The total radioactive strontium is determined in a shielded proportional counter and the difference between this concentration and that determined for Sr^{90} is reported as Sr^{89}. Stable calcium and potassium are also determined routinely on all samples (*8*).

Since initiation of the project, several of the analytical procedures have been improved or simplified. Prior to use, however, each new procedure was shown to have a precision and sensitivity equal to or better than the method replaced, thus making all of the data obtained in connection with the Raw Milk Surveillance Network comparable, with one exception. The initial radiochemical procedure for Cs^{137} was found to include a contribution from the beta-emitting Rb^{87} which is not detected in the gamma-spectrometer. Accordingly the Cs^{137} values from May 1957 to January 1959 may be high by as much as 15–20 pc per liter of milk as compared with later data. The I^{131}, Ba^{140} and Sr^{89} values have been corrected for decay to time of collection of the milk sample. In contrast to some of the already published data (*9, 10*) the observed concentrations of these nuclides have been rounded off to the nearest 5 pc in view of their minimum detectable concentrations.

Results and Discussion

To provide a convenient source of information generated in the Raw Milk Sampling Program, the results of all monthly milk samples collected from May 1957 through April 1963 are summarized in tables 1 through 7 for I^{131}, Ba^{140}, Sr^{89}, Sr^{90}, Cs^{137}, calcium, and potassium, respectively. Relationship between fallout and occurrence of fission products in milk as influenced by season of the year and the geographical location (*9, 10*), as well as the interrelationship between these data and those of other environmental media (*11*) have been discussed elsewhere. Accordingly, discussion in this text will be limited to: (a) the representativeness of the data; (b) a comparison of the results with the Pasteurized Milk Network, and (c) the observed gross differences in the levels of certain radionuclides in milk as observed with respect to time.

The data presented in tables 1–7 have been obtained from monthly milk samples representing 1 or 2 days of production rather than a composite of all the milk produced from one sampling period to the next. In assessing the representativeness of these data several avenues of investigation have led to the conclusion that this procedure is satisfactory for Sr^{90} and Cs^{137} and unsatisfactory for I^{131}, Ba^{140}, and Sr^{89}; direct confirmation of this view has been possible only recently when, for a period of time (October and November 1961), the frequency of sampling in the raw milk network was greatly increased in all the nine locations.

Analysis of composites of daily raw milk samples for Sr^{90} and Cs^{137} were made and compared with the single monthly samples. The results presented in table 8 show no significant differences between the single and composited samples for these nuclides during the limited period. Extension of this study in the Cincinnati area to a period (April to September 1962) of relatively rapid change in Sr^{90} content of the milk (Figure 1) also showed in this case that results between composited and single monthly samples are comparable within differences of 25–50 percent.

However, during periods of rapid change in Sr^{90}, the data presented in figure 1 also indicate that the time of collecting single monthly milk sample is rather important. Samples collected either at the beginning or at the end of each month may show Sr^{90} variations by as much as 25 to 75 percent. In the case of raw milk network, it has always been scheduled to collect single monthly samples during the middle of every month from

TABLE 1.—CONCENTRATION OF IODINE-131 IN RAW MILK, JUNE 1957—APRIL 1963

[pc/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
Jun	40	370	410	440	250	—	—	—	—
Jul	—	—	—	—	—	—	—	—	—
Aug	50	230	210	200	10	—	—	—	—
Sep	300	430	970	740	10	—	—	—	—
Oct	250	300	890	990	20	—	—	—	—
Nov	100	<10	<10	<10	<10	—	—	—	—
Dec	<10	<10	<10	50	<10	—	—	—	—
1958									
Jan	<10	<10	<10	<10	<10	—	—	—	—
Feb	<10	<10	<10	40	<10	—	—	—	—
Mar	<10	<10	<10	<10	<10	—	—	—	—
Apr	50	30	100	30	10	—	—	—	—
May	30	<10	<10	<10	<10	—	—	—	—
Jun	<10	<10	<10	<10	240	—	—	—	—
Jul	70	110	625	155	45	20	<10	125	—
Aug	70	40	60	80	20	65	50	45	55
Sep	10	5	20	15	<10	20	15	15	10
Oct	60	30	35	10	10	<10	10	20	<10
Nov	35	180	125	35	15	30	130	55	65
Dec	<10	<10	25	<10	15	20	40	<10	30
1959									
Jan	<10	<10	<10	<10	<10	<10	<10	<10	<10
Feb	<10	<10	<10	<10	<10	<10	10	<10	<10
Mar	<10	<10	<10	<10	<10	<10	<10	<10	<10
Apr	<10	<10	<10	<10	<10	<10	<10	<10	<10
May	<10	<10	<10	<10	<10	<10	10	<10	20
Jun	<10	<10	<10	<10	<10	16	<10	<10	<10
[a]									
1961									
Sep	50	240	10	170	<10	<10	<10	<10	<10
Oct	330	95	250	195	25	135	35	200	165
Nov	60	85	410	50	75	90	200	100	10
Dec	20	20	30	15	<10	50	40	15	<10
1962									
Jan	<10	<10	<10	<10	<10	15	20	<10	<10
Feb	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mar	<10	<10	<10	<10	<10	<10	<10	<10	<10
Apr	<10	<10	<10	<10	<10	20	20	<10	<10
May	35	40	535	15	<10	<10	<10	95	<10
Jun	<10	<10	40	<10	<10	35	20	20	<10
Jul	—	55	55	40	<10	<10	<10	40	130
Aug	<10	<10	20	175	<10	30	<10	25	25
Sep	40	35	100	45	25	15	<10	70	90
Oct	60	55	95	95	<10	45	15	70	70
Nov	55	245	355	55	15	55	50	60	20
Dec	<10	<10	85	—	<10	330	460	<10	20
1963									
Jan	<10	<10	20	<10	<10	15	40	<10	<10
Feb	<10	<10	<10	<10	<10	10	<10	<10	<10
Mar	<10	<10	<10	15	<10	<10	<10	<10	10
Apr	<10	<10	<10	<10	<10	<10	<10	<10	<10

[a] Note: From July 1959 through August 1961 I^{131} not detectable.

New York, Cincinnati, St. Louis, Salt Lake City, Sacramento, and Chicago, while the samples from Atlanta, Austin, and Spokane are collected during the first week of every month.

The pasteurized milk network was established mainly to obtain estimates of radionuclides consumed by large population in a given metropolitan city. It was thought, therefore, interesting at this time to compare the Sr^{90} concentrations in milk samples obtained by the raw and pasteurized milk network.

For comparison the Sr^{90} concentrations have been recorded over 26 months (table 9) in each of nine milksheds for the raw and pasteurized milk samples. The data were statistically analyzed to see if the mean Sr^{90} concentrations of raw milk samples differed significantly at $\alpha = 0.01$ from the Sr^{90} concentrations of pasteurized milk samples.

A paired 't' test was made to test the above hypothesis and the results are presented in table 9. The results indicate that at a significance level of $\alpha = 0.01$ the mean Sr^{90} values of raw and pasteurized milk samples from St. Louis and Atlanta were significantly different while that from New York was also significantly different at $\alpha = 0.05$. The validity of the difference between the mean Sr^{90} values of raw and pasteurized milk samples from New York was rejected considering the errors involved in determining Sr^{90} in milk.

Correlation coefficients between raw and pasteurized milk samples in each of the milksheds were computed and are included in table 9. The

TABLE 2.—CONCENTRATION OF BARIUM-140 IN RAW MILK, JUNE 1957—APRIL 1963

[pc/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
Jun	—	—	95	70	—	—	—	—	—
Jul	—	—	145	198	10	—	—	—	—
Aug	75	100	50	45	10	—	—	—	—
Sep	125	125	530	85	25	—	—	—	—
Oct	160	70	120	130	45	—	—	—	—
Nov	<10	15	<10	<10	45	—	—	—	—
Dec	<10	<10	15	<10	25	—	—	—	—
1958									
Jan	<10	<10	<10	<10	<10	—	—	—	—
Feb	<10	<10	<10	<10	<10	—	—	—	—
Mar	<10	<10	<10	<10	<10	—	—	—	
Apr	<10	<10	50	<10	20	—	—	—	—
May	<10	15	15	<10	10	—	—	—	—
Jun	20	35	45	20	<10	<10	<10	—	—
Jul	65	110	230	15	<10	12	<10	35	—
Aug	30	85	115	20	<10	50	20	20	15
Sep	15	15	50	15	<10	<10	<10	10	<10
Oct	15	<10	15	<10	<10	<10	<10	<10	<10
Nov	30	10	35	<10	15	<10	30	<10	50
Dec	—	<10	<10	<10	<10	<10	10	<10	<10
1959									
Jan	<10	<10	14	<10	<10	<10	<10	<10	<10
Feb	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mar	<10	<10	<10	<10	<10	<10	<10	<10	<10
•									
1961									
Sep	<10	10	<10	<10	<10	<10	<10	<10	<10
Oct	45	10	40	40	<10	10	<10	15	<10
Nov	20	10	75	50	15	10	45	25	<10
Dec	10	10	15	<10	<10	25	10	<10	<10
1962									
Jan	<10	10	20	<10	<10	25	20	15	<10
Feb	<10	15	<10	<10	<10	<10	<10	<10	<10
Mar	<10	<10	<10	<10	<10	<10	<10	<10	<10
Apr	<10	<10	15	<10	<10	<10	10	<10	<10
May	<10	<10	165	<10	<10	<10	<10	10	<10
Jun	<10	<10	25	<10	<10	<10	<10	35	<10
Jul	—	20	<10	15	<10	15	<10	<10	<10
Aug	<10	<10	15	35	<10	10	<10	<10	<10
Sep	<10	<10	20	10	<10	<10	<10	<10	20
Oct	20	20	20	<10	15	<10	<10	15	<10
Nov	25	30	65	<10	<10	<10	15	20	<10
Dec	30	<10	20	—	<10	45	50	<10	<10
1963									
Jan	<10	<10	<10	<10	<10	10	<10	<10	<10
Feb	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mar	<10	<10	<10	<10	<10	<10	<10	<10	<10
Apr	<10	<10	<10	<10	<10	<10	<10	<10	<10

• Note: From April 1959 through August 1961 Ba^{140} not detectable.

results shown that except for samples from Sacramento, the correlation between sample types are good. The negative and poor correlation observed in Sacramento may be due to several factors including low level of Sr^{90}, sample variation, and errors involved in determining low Sr^{90} levels.

The above analysis suggests that except for St. Louis and Atlanta the data for raw milk may be used as such to estimate Sr^{90} concentrations in pasteurized milk for the time period not covered by the Pasteurized Milk Network. Although there is no satisfactory explanation to account for the differences in the St. Louis findings, one possibility may lie in the marked differences in geological characteristics of the land and farming practices in the several areas comprising these milksheds.

In contrast to long-lived radionuclides, short-lived radionuclides in milk have been found to be present only during and immediately following weapons-test activity, after which the levels in milk closely parallel the decay of the radionuclides. It is evident, therefore, that single observations made at monthly intervals provide only an indication of its presence and would not represent the actual levels during the intervening period. Such discrepancies are clearly shown in figure 2, which compares I^{131} levels in milk collected on an every other day basis and estimates from single monthly samples. Similar observations were made in milk samples collected from all the nine milksheds during October-November 1961.

The data collected from radiation surveillance networks are customarily interpreted in terms of the differences observed between samples within a relatively short interval of time. Under such conditions for example, the levels of Sr^{90} and Cs^{137}

TABLE 3.—CONCENTRATION OF STRONTIUM-89 IN RAW MILK, AUGUST 1957—APRIL 1963

[pc/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
Aug	110	125	120	105	40	—	—	—	—
Sep	125	100	360	85	20	—	—	—	—
Oct	190	200	215	150	35	—	—	—	—
Nov	50	75	100	35	15	—	—	—	—
Dec	25	20	45	20	35	—	—	—	—
1958									
Jan	10	<5	35	15	<5	—	—	—	—
Feb	5	10	20	10	5	—	—	—	—
Mar	5	10	30	5	25	—	—	—	—
Apr	5	20	50	5	115	—	—	—	—
May	40	120	170	45	65	—	—	—	—
Jun	95	160	175	110	60	55	35	—	—
Jul	135	295	485	40	35	60	25	95	—
Aug	60	150	380	70	50	175	60	95	90
Sep	120	150	450	75	25	115	50	150	70
Oct	145	100	235	40	20	110	50	85	75
Nov	85	165	245	20	25	45	85	90	60
Dec	20	60	145	10	20	40	50	25	85
1959									
Jan	15	50	120	10	20	90	40	10	80
Feb	10	20	120	5	15	90	55	—	25
Mar	5	30	210	5	95	160	110	10	10
Apr	10	60	280	10	60	210	105	10	25
May	30	75	220	50	40	150	60	90	145
Jun	45	45	130	40	15	65	35	30	85
Jul	75	25	40	30	10	30	10	30	45
Aug	45	13	20	5	5	25	20	15	35
Sep	<5	5	15	<5	<5	15	<5	10	15
Oct	<5	<5	20	<5	<5	5	<5	5	<5
[a]									
1961									
Sep	<5	10	5	<5	<5	<5	<5	<5	<5
Oct	35	15	75	30	<5	15	<5	35	<5
Nov	40	45	170	<5	25	<5	45	75	<5
Dec	<5	9	40	<5	25	75	40	<5	<5
1962									
Jan	<5	<5	55	<5	5	110	100	<5	<5
Feb	<5	<5	185	<5	15	215	20	<5	<5
Mar	<5	5	155	<5	90	175	30	<5	<5
Apr	<5	40	305	<5	35	235	55	<5	<5
May	50	50	230	5	30	180	35	15	30
Jun	40	80	140	20	10	65	25	40	50
Jul	105	100	80	25	10	30	15	25	50
Aug	15	20	30	35	<5	20	5	15	10
Sep	150	20	40	9	<5	8	<5	20	20
Oct	70	45	60	20	10	215	5	55	15
Nov	205	80	185	10	20	20	59	24	20
Dec	25	5	335	<5	80	115	105	<5	30
1963									
Jan	<5	10	90	<5	10	95	70	<5	<5
Feb	<5	<5	75	25	25	65	35	<5	<5
Mar	<5	5	130	<5	30	80	30	<5	<5
Apr	<5	80	180	<5	180	95	45	10	<5

[a] Note: From November 1959 through August 1961 Sr^{89} not detectable.

in milk have been found to be considerably more dependent on factors related to the season of the year than on the deposition of these radionuclides. On the other hand, when the raw milk data are averaged on a yearly basis to minimize seasonal fluctuations and then plotted as a function of time as has been done in figures 3 and 4, a clear association is seen between a high level of activity in milk and periods of weapons tests (1958–59 and again in 1961) and decreased levels of activity during the intervening period. This presentation also reveals similarity among the widely separated areas in the trend of concentrations of these fission products in milk.

Table 10 presents a summary of the monthly data shown in tables 1–7. During the years 1957 through 1962, the short-lived radionuclides iodine-131 and Ba^{140} ranged from non-detectable to a maximum monthly average of 990 pc/liter for I^{131} and 530 pc/liter for Ba^{140}. Concentrations were very low or non-detectable during 1959 and 1960. However, concentrations of these radionuclides in milk were seen to increase in 1961 and 1962. It should be noted that the maximum of the monthly averages for 1961 and 1962 were about half of the values recorded for the period 1957–58. Although increases were noted in the maximum values during 1961–62, the median values for I^{131} and Ba^{140} indicate that at least half of the stations for at least six months of each of these two years were still reporting non-detectable values.

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TABLE 4.—CONCENTRATION OF STRONTIUM-90 IN RAW MILK, MAY 1957—APRIL 1963

[pc/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
May	4.6	5.5	10.1	4.6	4.5	—	—	—	—
Jun	5.1	6.7	12.9	6.4	7.0	—	—	—	—
Jul	8.7	5.1	11.0	4.9	8.6	—	—	—	—
Aug	6.9	4.4	7.7	4.1	1.9	—	—	—	—
Sep	6.1	5.0	9.1	4.3	1.5	—	—	—	—
Oct	5.0	7.7	9.7	5.5	1.7	—	—	—	—
Nov	5.2	7.0	7.8	4.8	9.6	—	—	—	—
Dec	5.0	5.9	7.1	3.0	5.0	—	—	—	—
1958									
Jan	5.6	4.1	7.9	3.0	5.9	—	—	—	—
Feb	5.2	3.9	7.0	2.2	3.8	—	—	—	—
Mar	3.9	4.1	10.0	3.0	4.2	—	—	—	—
Apr	4.0	6.4	12.3	4.7	10.5	—	—	—	—
May	3.6	8.6	10.0	3.3	3.8	—	—	—	—
Jun	9.9	11.6	14.8	7.1	7.1	13.7	2.2	—	—
Jul	10.5	13.0	18.7	4.7	3.3	10.2	3.5	7.1	—
Aug	3.3	7.5	14.1	4.2	6.8	11.9	3.4	9.3	6.9
Sep	5.6	9.4	15.4	5.0	3.8	13.8	3.9	7.9	8.2
Oct	9.5	8.6	12.2	3.1	1.4	10.4	5.1	6.0	8.6
Nov	8.8	15.2	20.1	5.2	6.1	8.8	3.7	8.4	11.9
Dec	7.9	9.6	15.6	6.1	4.2	10.2	2.6	7.0	8.6
1959									
Jan	6.9	11.7	18.6	4.5	4.3	13.4	5.7	6.7	9.1
Feb	6.5	12.2	19.6	3.4	3.9	7.3	6.3	6.8	6.3
Mar	6.5	12.9	22.5	4.6	7.7	14.0	7.3	5.5	10.9
Apr	7.6	16.5	37.3	5.4	7.5	20.8	8.9	7.2	10.5
May	12.0	18.2	34.6	9.8	8.6	22.8	6.5	12.5	22.6
Jun	14.0	17.4	11.2	11.8	6.4	19.9	8.2	12.1	22.1
Jul	14.6	10.5	17.6	9.4	4.3	15.9	6.3	11.7	18.3
Aug	12.3	12.4	19.6	7.5	3.0	14.3	4.2	9.3	5.9
Sep	4.2	6.6	15.0	5.1	1.0	13.8	2.7	5.2	5.6
Oct	8.3	9.3	25.1	6.5	3.6	13.2	3.8	10.1	9.8
Nov	9.3	12.4	24.0	5.4	6.1	15.7	5.3	8.4	12.1
Dec	9.2	13.8	21.8	6.4	3.7	14.3	7.0	8.1	13.1
1960									
Jan	10.2	11.5	21.8	7.5	2.7	12.8	7.3	9.2	13.9
Feb	9.9	11.4	18.8	6.2	1.7	19.3	6.8	8.6	12.8
Mar	10.9	12.3	20.3	10.0	4.2	18.7	4.8	10.1	12.6
Apr	10.2	13.5	23.4	7.0	4.6	15.8	4.4	9.4	14.9
May	12.3	8.3	23.3	8.4	4.1	19.8	4.5	14.6	15.2
June	9.3	10.0	18.1	7.2	4.3	12.0	2.6	12.6	17.3
Jul	10.3	10.4	16.1	3.9	3.3	13.0	3.1	9.2	10.0
Aug	8.1	10.3	15.9	4.6	2.8	13.3	3.0	7.7	9.2
Sep	7.6	7.9	15.1	5.3	4.1	14.1	3.0	7.1	7.5
Oct	7.0	7.2	15.1	4.1	2.4	12.6	3.9	8.9	7.5
Nov	9.0	8.8	13.7	3.4	2.7	12.5	4.0	7.7	6.8
Dec	7.5	7.3	14.4	4.8	2.2	10.7	3.8	8.1	6.4
1961									
Jan	7.9	7.8	12.8	2.9	3.7	12.5	3.8	3.5	4.6
Feb	9.0	8.1	12.2	5.7	6.8	14.6	5.2	5.7	8.8
Mar	6.5	8.0	13.3	2.3	2.8	11.3	3.5	8.4	7.8
Apr	6.8	9.9	19.9	2.8	2.4	11.2	2.8	9.0	6.8
May	8.6	10.5	22.5	3.3	3.5	13.7	2.4	7.5	8.4
Jun	9.0	9.6	23.0	3.9	2.7	12.8	3.4	5.0	8.3
Jul	6.0	6.6	14.4	2.6	1.8	10.2	3.3	4.8	7.5
Aug	5.4	7.3	12.9	3.1	2.0	10.0	2.2	6.8	5.5
Sep	4.0	6.4	12.8	2.8	1.3	8.4	2.9	5.3	3.5
Oct	4.8	6.2	10.7	3.8	1.0	11.9	3.0	6.4	10.4
Nov	5.5	8.1	17.1	4.2	2.2	13.6	3.9	6.6	5.9
Dec	7.4	9.3	13.7	3.8	2.0	10.8	5.7	6.9	5.6
1962									
Jan	7.1	8.0	16.0	3.4	2.2	13.4	3.9	4.3	5.8
Feb	6.9	8.0	18.9	2.6	1.6	21.7	3.8	6.2	7.7
Mar	5.6	10.0	28.5	3.6	9.1	17.6	6.4	6.3	8.3
Apr	6.6	9.2	45.6	3.0	6.1	29.7	8.7	6.2	7.4
May	14.7	14.5	37.6	5.2	5.8	32.0	6.5	14.2	11.4
Jun	15.5	18.5	39.2	8.2	5.7	23.0	6.1	14.3	15.7
Jul	15.3	19.3	29.8	11.5	5.4	19.6	6.4	12.4	15.7
Aug	18.5	16.8	31.5	12.0	4.6	19.7	4.6	15.0	14.7
Sep	16.5	13.7	28.8	9.9	3.5	21.7	5.0	11.2	14.0
Oct	19.3	16.5	45.6	10.4	4.0	19.2	5.6	13.6	16.5
Nov	16.5	18.8	40.7	13.0	5.3	15.6	6.1	14.3	18.3
Dec	13.5	17.1	38.5	15.4	6.0	20.7	7.4	15.5	16.9
1963									
Jan	14.0	17.1	29.1	12.4	5.0	22.6	7.2	12.6	16.8
Feb	17.6	13.1	28.4	12.1	4.0	19.4	7.5	10.5	14.7
Mar	10.9	14.4	27.1	9.7	9.7	16.4	7.1	9.6	13.0
Apr	10.8	21.1	46.4	8.5	24.4	24.6	9.5	9.3	10.6

TABLE 5.—CONCENTRATION OF CESIUM-137 IN RAW MILK, MAY 1957—APRIL 1963

[pc/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
May	40	25	20	30	30	—	—	—	—
Jun	30	35	70	55	40	—	—	—	—
Jul	25	35	60	50	50	—	—	—	—
Aug	50	40	35	40	80	—	—	—	—
Sep	70	55	65	155	45	—	—	—	—
Oct	50	40	65	45	40	—	—	—	—
Nov	45	35	35	45	50	—	—	—	—
Dec	40	40	50	35	35	—	—	—	—
1958									
Jan	30	50	40	40	45	—	—	—	—
Feb	45	55	45	65	45	—	—	—	—
Mar	50	60	55	80	50	—	—	—	—
Apr	45	50	60	65	100	—	—	—	—
May	—	—	—	—	—	—	—	—	—
Jun	—	—	—	—	—	—	—	—	—
Jul	45	65	90	25	15	55	25	45	—
Aug	35	35	60	30	20	50	20	40	55
Sep	30	—	60	30	15	40	20	30	30
Oct	35	25	50	20	15	45	15	30	55
Nov	45	55	60	25	20	25	30	40	55
Dec	40	40	50	15	15	45	30	55	55
1959									
Jan	45	45	65	25	20	60	20	45	65
Feb	60	30	50	35	40	60	40	60	70
Mar	45	55	90	—	45	90	55	50	70
Apr	35	45	100	20	40	105	50	55	60
May	55	65	160	65	35	100	50	65	120
Jun	40	45	110	60	20	75	45	63	85
Jul	45	35	80	—	15	60	30	54	65
Aug	35	15	75	30	5	—	20	35	40
Sep	15	10	35	30	10	40	15	30	40
Oct	20	15	45	35	15	30	15	25	45
Nov	35	40	40	35	15	40	25	40	50
Dec	40	35	45	35	10	70	20	35	85
1960									
Jan	45	45	40	40	10	45	25	35	50
Feb	45	40	35	40	10	65	25	45	55
Mar	40	40	45	55	20	65	25	40	60
Apr	45	35	40	55	10	55	15	50	60
May	40	15	35	35	10	40	20	45	45
Jun	25	15	30	25	5	35	25	30	35
Jul	10	25	30	20	10	30	10	30	25
Aug	10	10	10	40	5	20	15	15	25
Sep	10	10	20	15	5	20	10	20	25
Oct	5	10	25	20	5	—	—	15	15
Nov	20	15	25	10	10	20	5	15	20
Dec	15	20	15	5	5	20	10	15	20
1961									
Jan	15	10	20	5	<5	25	<5	15	15
Feb	20	15	20	10	10	25	10	20	15
Mar	20	25	30	20	20	30	15	20	20
Apr	20	15	20	<5	5	25	10	15	15
May	15	15	35	10	15	20	<5	25	15
Jun	15	15	20	20	<5	25	10	25	20
Jul	10	15	20	10	10	25	10	10	35
Aug	10	20	15	5	<5	15	<5	10	25
Sep	5	5	20	10	<5	15	<5	<5	20
Oct	15	5	25	15	<5	10	<5	5	15
Nov	15	15	30	30	15	10	30	10	20
Dec	20	20	30	15	20	25	10	30	20
1962									
Jan	45	25	35	10	10	30	20	25	25
Feb	20	25	35	<5	5	60	15	20	20
Mar	25	15	65	10	<5	70	15	20	20
Apr	20	20	90	<5	30	115	30	20	20
May	50	30	140	20	35	180	30	50	40
Jun	75	60	135	55	25	105	35	95	100
Jul	55	50	95	65	15	85	25	70	90
Aug	10	35	85	75	20	60	25	75	85
Sep	65	30	65	70	15	55	15	45	65
Oct	90	40	75	55	15	45	20	75	75
Nov	75	60	90	90	25	45	20	65	90
Dec	90	70	85	—	20	75	35	70	85
1963									
Jan	75	75	100	105	25	85	30	75	85
Feb	65	60	100	80	25	90	30	75	90
Mar	70	65	110	90	45	95	30	75	90
Apr	60	65	115	55	120	100	60	70	75

TABLE 6.—CONCENTRATION OF CALCIUM IN RAW MILK, MAY 1957—APRIL 1963

[g/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1957									
May	1.01	1.15	1.20	1.11	1.13	—	—	—	—
Jun	1.05	1.15	1.20	1.12	1.09	—	—	—	—
Jul	1.03	1.14	1.20	1.12	1.10	—	—	—	—
Aug	1.04	1.14	1.20	1.13	1.11	—	—	—	—
Sep	1.06	1.16	1.20	1.13	1.09	—	—	—	—
Oct	1.12	1.22	1.27	1.17	1.14	—	—	—	—
Nov	1.10	1.19	1.30	1.17	1.15	—	—	—	—
Dec	1.12	1.16	1.31	1.17	1.16	—	—	—	—
1958									
Jan	1.12	1.18	1.32	1.16	1.17	—	—	—	—
Feb	1.09	1.15	1.31	1.09	1.12	—	—	—	—
Mar	1.05	1.08	1.27	1.16	1.15	—	—	—	—
Apr	1.08	1.14	1.24	1.13	1.15	—	—	—	—
May	1.04	1.16	1.26	1.14	1.14	—	—	—	—
Jun	1.09	1.23	1.22	1.13	1.12	1.16	1.12	—	—
Jul	1.06	1.08	1.18	1.07	1.04	1.16	1.14	1.07	—
Aug	1.04	1.10	1.23	1.10	1.12	1.17	1.16	1.06	1.16
Sep	1.24	1.13	1.29	1.21	1.16	1.15	1.12	1.16	1.16
Oct	1.14	1.18	1.27	1.19	1.11	1.22	1.15	1.12	1.20
Nov	1.10	1.16	1.28	1.16	1.11	1.19	1.17	1.14	1.22
Dec	1.11	1.15	1.27	1.16	1.17	1.21	1.18	1.10	1.24
1959									
Jan	1.06	1.14	1.33	1.14	1.15	1.24	1.22	1.13	1.27
Feb	1.12	1.16	1.28	1.18	1.15	1.22	1.15	1.12	1.18
Mar	1.11	1.15	1.23	1.18	1.13	1.25	1.17	1.09	1.24
Apr	1.11	1.17	1.30	1.12	1.15	1.18	1.16	1.14	1.17
May	1.15	1.15	1.23	1.13	1.15	1.27	1.18	1.13	1.16
Jun	1.14	1.15	1.28	1.12	1.14	1.25	1.12	1.16	1.16
Aug	1.04	1.10	1.18	1.05	1.08	1.18	1.02	1.04	1.03
Sep	1.01	1.18	1.27	1.12	1.12	1.12	1.15	1.13	1.23
Oct	1.01	1.05	1.24	1.09	1.03	1.10	1.05	1.10	1.11
Nov	1.09	1.15	1.32	1.09	1.07	1.06	1.05	1.05	1.09
Dec	1.08	1.16	1.26	1.15	1.16	1.18	1.16	1.12	1.19
1960									
Jan	1.08	1.11	1.35	1.13	1.16	1.24	1.15	1.15	1.25
Feb	1.06	1.05	1.37	1.09	1.06	1.11	1.12	1.01	1.14
Mar	1.09	1.09	1.17	1.11	1.04	1.12	1.14	1.06	1.06
Apr	1.19	1.19	1.16	1.09	1.08	1.11	1.12	1.18	1.05
May	1.05	1.15	1.18	1.06	1.11	1.15	1.04	1.09	1.10
Jun	1.11	1.22	1.18	1.11	1.17	1.04	1.02	1.14	1.04
Jul	1.01	1.01	1.13	1.05	1.05	1.10	1.03	1.02	1.08
Aug	1.00	1.05	1.10	1.06	1.09	1.06	1.05	1.01	1.10
Sep	1.08	1.05	1.10	1.05	1.15	1.11	1.10	1.12	1.13
Oct	1.14	1.28	1.30	—	1.19	1.11	1.23	1.16	1.12
Nov	1.20	1.21	1.27	1.22	1.21	1.29	1.23	1.19	1.27
Dec	1.11	1.18	1.29	1.17	1.21	1.25	1.15	1.10	1.24
1961									
Jan	1.14	1.23	1.29	1.19	1.17	1.23	1.22	1.16	1.23
Feb	1.08	1.22	1.24	1.15	1.22	1.17	1.12	1.20	1.18
Mar	1.11	1.18	1.24	1.23	1.19	1.15	1.12	1.15	1.18
Apr	1.12	1.17	1.18	1.18	1.16	1.19	1.17	1.14	1.14
May	1.15	1.17	1.24	1.16	1.14	1.16	1.15	1.13	1.16
Jun	1.14	1.18	1.24	1.16	1.16	1.19	1.15	1.11	1.15
Jul	1.14	1.19	1.21	1.11	1.12	1.17	1.16	1.10	1.16
Aug	1.14	1.15	1.20	1.14	1.11	1.18	1.15	1.12	1.17
Sep	1.13	1.18	1.24	1.14	1.10	1.16	1.12	1.12	1.13
Oct	1.13	1.17	1.24	1.17	1.12	1.16	1.14	1.10	1.16
Nov	1.07	1.16	1.24	1.14	1.16	1.15	1.15	1.08	1.15
Dec	1.13	1.18	1.27	1.15	1.16	1.16	1.13	1.13	1.16
1962									
Jan	1.12	1.18	1.22	1.16	1.16	1.17	1.13	1.10	1.16
Feb	1.12	1.16	1.26	1.15	1.15	1.16	1.12	1.13	1.16
Mar	1.06	1.16	1.25	1.14	1.14	1.19	1.11	1.10	1.15
Apr	1.11	1.18	1.28	1.17	1.18	1.21	1.14	1.18	1.18
May	1.16	1.20	1.29	1.13	1.19	1.22	1.15	1.18	1.24
Jun	1.15	1.17	1.23	1.14	1.17	1.19	1.16	1.15	1.16
Jul	1.10	1.16	1.22	1.14	1.16	1.17	1.12	1.09	1.16
Aug	1.08	1.16	1.19	1.12	1.14	1.16	1.10	1.08	1.18
Sep	1.06	1.18	1.26	1.15	1.14	1.18	1.10	1.13	1.20
Oct	1.12	1.20	1.23	1.11	1.17	1.15	1.11	1.14	1.14
Nov	1.07	1.17	1.23	1.13	1.15	1.17	1.12	1.11	1.19
Dec	1.05	1.23	1.23	1.12	1.13	1.21	1.13	1.09	1.24
1963									
Jan	1.05	1.13	1.20	1.12	1.12	1.13	1.09	1.09	1.09
Feb	1.08	1.13	1.19	1.14	1.14	1.16	1.11	1.09	1.17
Mar	1.07	1.14	1.20	1.09	1.10	1.14	1.08	1.12	1.14
Apr	1.05	1.09	1.18	1.07	1.11	1.11	1.06	1.08	1.10

Table 7.—CONCENTRATION OF POTASSIUM IN RAW MILK, AUGUST 1958—APRIL 1963

[g/liter]

Month	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Austin	Chicago	Spokane
1958									
Aug	1.51	1.46	1.31	1.51	1.57	1.46	—	1.43	1.45
Sep	1.37	1.42	1.38	1.45	1.54	1.45	1.44	1.46	1.49
Oct	1.53	1.50	1.37	1.55	1.52	1.49	1.39	1.48	1.45
Nov	1.56	1.50	1.38	1.52	1.48	1.55	1.50	1.50	1.50
Dec	1.61	1.48	1.36	1.54	1.53	1.49	1.49	1.55	1.53
1959									
Jan	1.48	1.55	1.40	1.47	1.46	1.45	1.36	1.50	1.50
Feb	1.55	1.42	1.36	1.51	1.46	1.42	1.43	1.46	1.45
Mar	1.65	1.44	1.38	1.46	1.46	1.47	1.44	1.48	1.51
Apr	1.50	1.42	1.35	1.46	1.43	1.42	1.45	1.51	1.47
May	1.50	1.48	1.36	1.48	1.46	1.40	1.44	1.47	1.45
Jun	1.50	1.46	1.50	1.51	1.51	1.39	1.45	1.46	1.45
Jul	1.37	1.34	1.45	1.45	1.33	1.44	1.45	1.43	1.44
Aug	1.45	1.39	1.36	1.41	1.45	1.38	1.43	1.38	1.35
Sep	1.27	1.45	1.32	1.38	1.40	1.38	1.41	1.44	1.38
Oct	1.41	1.38	1.26	1.42	1.42	1.45	1.40	1.40	1.44
Nov	1.51	1.40	1.28	1.39	1.41	1.38	1.42	1.41	1.41
Dec	1.44	1.39	1.28	1.41	1.42	1.40	1.37	1.42	1.42
1960									
Jan	1.45	1.38	1.31	1.47	1.45	1.43	1.37	1.43	1.44
Feb	1.42	1.33	1.27	1.44	1.30	1.37	1.39	1.49	1.32
Mar	1.46	1.27	1.33	1.54	1.37	1.34	1.28	1.42	1.42
Apr	1.39	1.29	1.30	1.37	1.19	1.31	1.28	1.39	1.36
May	1.43	1.20	1.20	1.21	1.27	1.18	1.26	1.27	1.20
Jun	1.36	1.44	1.26	1.19	1.32	1.24	1.32	1.44	1.28
Jul	1.41	1.44	1.50	1.53	1.43	1.22	1.28	1.37	1.35
Aug	1.42	1.49	1.43	1.36	1.35	1.46	1.53	1.37	1.44
Sep	1.48	1.44	1.35	1.53	1.54	1.34	1.45	1.47	1.41
Oct	1.52	1.50	1.38	—	1.47	1.42	1.43	1.46	1.37
Nov	1.35	1.50	1.35	1.48	1.47	1.37	1.42	1.44	1.40
Dec	1.44	1.46	1.32	1.40	1.40	1.30	1.34	1.42	1.34
1961									
Jan	1.43	1.40	1.44	1.39	1.47	1.49	1.42	1.45	1.40
Feb	1.55	1.46	1.42	1.50	1.52	1.47	1.52	1.52	1.42
Mar	1.50	1.49	1.41	1.53	1.54	1.37	1.37	1.54	1.42
Apr	1.46	1.40	1.38	1.43	1.37	1.38	1.50	1.42	1.46
May	1.49	1.47	1.48	1.48	1.48	1.36	1.40	1.43	1.42
Jun	1.44	1.44	1.40	1.44	1.45	1.46	1.47	1.45	1.45
Jul	1.46	1.46	1.39	1.43	1.44	1.43	1.48	1.41	1.45
Aug	1.50	1.40	1.41	1.50	1.49	1.47	1.51	1.48	1.48
Sep	1.46	1.49	1.51	1.45	1.36	1.15	1.45	1.47	1.43
Oct	1.44	1.49	1.45	1.52	1.51	1.42	1.42	1.41	1.45
Nov	1.39	1.43	1.40	1.48	1.52	1.38	1.46	1.44	1.48
Dec	1.53	1.50	1.39	1.46	1.48	1.46	1.45	1.48	1.49
1962									
Jan	1.50	1.51	1.38	1.51	1.44	1.47	1.49	1.51	1.49
Feb	1.51	1.46	[illegible]	1.48	1.50	1.50	1.49	1.47	1.47
Mar	1.56	1.46	[illegible]	1.49	1.51	1.49	1.47	1.49	1.48
Apr	1.70	1.51	[illegible]	1.50	1.52	1.47	1.44	1.54	1.53
May	1.65	1.48	[illegible]	1.57	1.55	1.46	1.53	1.55	1.52
Jun	1.57	1.44	[illegible]	1.55	1.54	1.51	1.49	1.52	1.51
Jul	1.66	1.51	1.50	1.50	1.52	1.53	1.58	1.49	1.59
Aug	1.59	1.53	1.52	1.53	1.54	1.62	1.58	1.53	1.59
Sep	1.52	1.54	1.54	1.63	1.60	1.54	1.60	1.55	1.56
Oct	1.51	1.57	1.35	1.40	1.55	1.40	1.46	1.60	1.44
Nov	1.54	1.48	1.41	1.58	1.56	1.53	1.56	1.58	1.58
Dec	1.53	1.62	1.44	1.49	1.52	1.52	1.52	1.51	1.58
1963									
Jan	1.50	1.50	1.45	1.46	1.48	1.46	1.53	1.56	1.53
Feb	1.53	1.50	1.46	1.55	1.54	1.44	1.48	1.56	1.48
Mar	1.51	1.49	1.46	1.53	1.47	1.42	1.49	1.57	1.48
Apr	1.56	1.51	1.47	1.49	1.45	1.42	1.52	1.49	1.54

Strontium-89, which was present in milk during 1957–59, decreased to non-detectable levels for the network in 1960. Through 1962, concentrations rose at some locations to about the previously observed values of 1957–59, but the median values indicate that more stations were reporting lower levels in 1961–62 than in the late fifties.

The appearance of the long-lived isotopes Sr^{90} and Cs^{137} in milk follows a very different pattern from the short-lived radionculides. Rapid fluctuation of concentrations of radionculides with a long half-life does not occur. Strontium-90 levels in milk rose, beginning in 1957, reaching a peak in 1959. Cesium-137 concentrations for the network generally did not change during these years. Both Sr^{90} and Cs^{137} showed decreasing trends during 1960–61. However, in 1962 Cs^{137} concentrations in milk rose again to the levels present in the late fifties, while Sr^{90} concentrations in milk had risen in 1962 to levels exceeding those recorded in the previous high year, 1959.

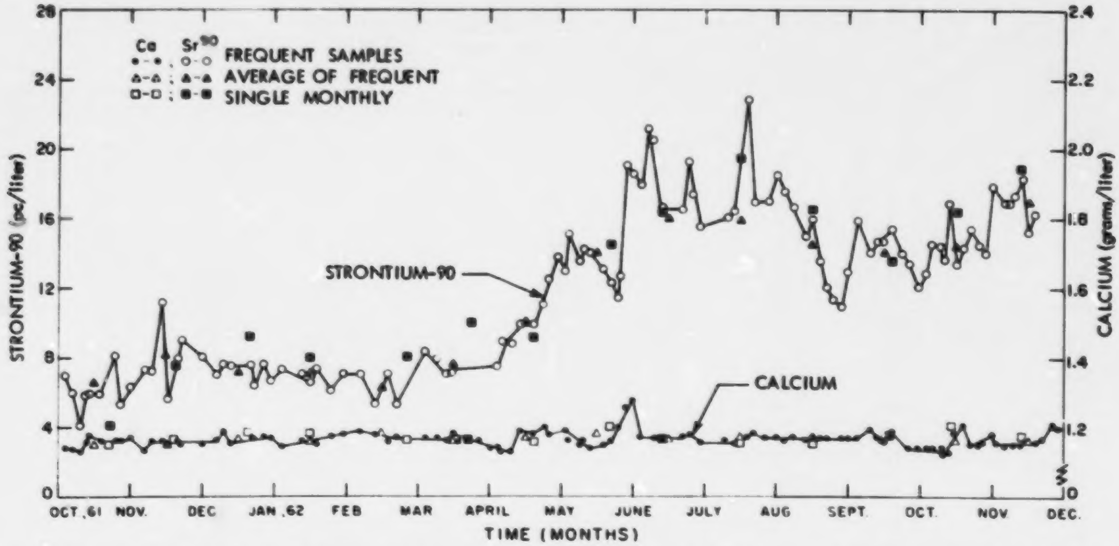

FIGURE 1.—INFLUENCE OF SAMPLING FREQUENCY ON THE OBSERVED STRONTIUM-90 AND CALCIUM CONCENTRATIONS IN MILK (CINCINNATI, OHIO STATION)

TABLE 8.—COMPARISON OF SINGLE *VS* MONTHLY COMPOSITES ON THE STRONTIUM-90 AND CESIUM-137 CONTENTS OF MILK

[Concentrations in pc/liter]

Sample		Sr^{90}		Cs^{137}	
Area	Month	Single	Composite	Single	Composite
	(1961)				
New York	Oct	4.8	[a]5.9 (15)	15	10 (15)
	Nov	5.5	6.4 (22)	15	15 (22)
Cincinnati	Oct	6.3	6.0 (11)	5	10 (11)
	Nov	8.1	8.5 (8)	15	15 (8)
St. Louis	Oct	10.7	14.5 (29)	25	20 (29)
	Nov	17.1	18.1 (29)	30	30 (29)
Salt Lake City	Oct	3.8	3.2 (10)	15	10 (10)
	Nov	4.2	4.8 (12)	30	15 (12)
Sacramento	Oct	1.0	1.0 (15)	5	10 (15)
	Nov	2.2	1.7 (23)	15	5 (23)
Atlanta	Oct	11.9	12.6 (18)	10	10 (18)
	Nov	13.6	14.3 (22)	10	20 (22)
Austin	Oct	3.0	2.5 (12)	5	5 (12)
	Nov	3.9	2.9 (11)	10	10 (11)
Chicago	Oct	6.4	6.1 (13)	5	15 (13)
	Nov	6.6	6.0 (19)	30	20 (19)
Spokane	Oct	10.4	7.5 (15)	15	20 (15)
	Nov	5.9	6.0 (25)	20	25 (25)

Analysis of Variance between Single vs Monthly Composites of Milk

Nuclide	Source	Degrees of Freedom	Mean Square	Variance Ratio	Significance
Sr^{90}	Method	1	0.1882	0.22	Not Significant
	Milk	17	40.3268	46.6	1%
	Error	17	0.8648		
	Total	35			
Cs^{137}	Method	1	2.78	0.12	Not Significant
	Milk	17	97.05	4.15	Not Significant
	Error	17	23.27		
	Total	35			

[a] Figures in parenthesis represent number of samples in composite.

TABLE 9.—COMPARISON OF STRONTIUM-90 CONCENTRATIONS IN MILK SAMPLES FROM RAW AND PASTEURIZED MILK NETWORKS

Month	New York		Cincinnati		St. Louis		Salt Lake City		Sacramento		Atlanta		Austin		Chicago		Spokane	
	Raw	Past	Raw	Past	Raw	Past	Raw	Past	Raw	Past	Raw	Past	Raw	Past	Raw	Past	Raw	Past
1960																		
Aug	8	8	10	9	16	6	5	4	4	3	13	11	3	3	8	6	9	5
Sep	8	8	8	8	15	7	5	6	4	6	14	11	3	3	7	6	8	7
Nov	9	10	9	8	14	7	3	5	3	3	12	[illegible]	4	1	8	6	7	7
Dec	8	7	7	8	14	10	5	5	2	6	11	[illegible]	4	2	8	6	6	6
1961																		
Feb	9	6	8	8	12	6	6	3	7	2	15	6	5	2	6	5	9	5
Mar	7	8	8	7	13	8	2	5	3	4	11	6	4	2	8	6	8	7
Apr	7	8	10	8	20	8	3	4	2	6	11	8	3	3	9	9	7	6
May	9	10	11	10	23	7	3	8	4	4	14	13	2	4	8	6	8	9
Jun	9	10	10	10	23	10	4	4	3	6	13	10	3	3	5	8	8	10
Jul	6	10	7	10	14	7	3	5	2	5	10	10	3	2	5	6	8	8
Aug	5	6	7	7	13	6	3	4	2	4	10	10	2	2	7	4	6	12
Sep	4	10	6	10	13	10	3	5	1	6	8	9	3	3	5	5	4	6
Oct	5	8	6	6	11	11	4	7	1	8	12	12	3	4	6	9	10	6
Nov	6	8	8	9	17	10	4	4	2	4	14	10	4	4	7	6	6	6
Dec	7	9	9	10	14	8	4	5	2	3	11	12	6	6	7	7	6	7
1962																		
Jan	7	12	8	10	15	7	3	5	2	2	13	11	4	5	4	6	6	6
Feb	7	8	8	11	19	7	3	4	2	3	22	15	4	5	6	6	8	6
Mar	6	8	10	10	28	8	4	3	9	4	18	14	6	7	6	5	8	6
Apr	7	14	9	19	46	14	3	7	6	5	30	20	9	8	6	12	7	16
Jun	16	14	19	19	39	23	8	14	6	5	23	20	6	8	14	15	16	18
Jul	15	15	19	14	30	19	12	12	5	4	20	22	6	8	12	12	16	15
Aug	18	14	17	14	32	16	12	13	5	2	20	18	5	6	15	14	15	14
Sep	16	20	14	12	29	12	10	10	4	2	22	17	5	5	11	15	14	12
Oct	19	23	16	13	46	16	10	10	4	2	19	18	6	7	14	14	16	15
Nov	16	16	19	20	41	12	13	12	4	4	16	15	6	8	14	13	18	14
Dec	14	11	17	14	39	14	15	10	6	4	21	17	7	10	16	9	17	17
Statistical data																		
't'	[a] −2.62		0.27		[b] 7.44		−2.08		−0.81		[b] 4.87		−0.64		0.33		0.40	
Correlation coefficient	0.80		0.76		0.74		0.80		−0.30		0.83		0.80		0.75		0.73	

[a] Significant at $\alpha = 0.05$
[b] Significant at $\alpha = 0.01$

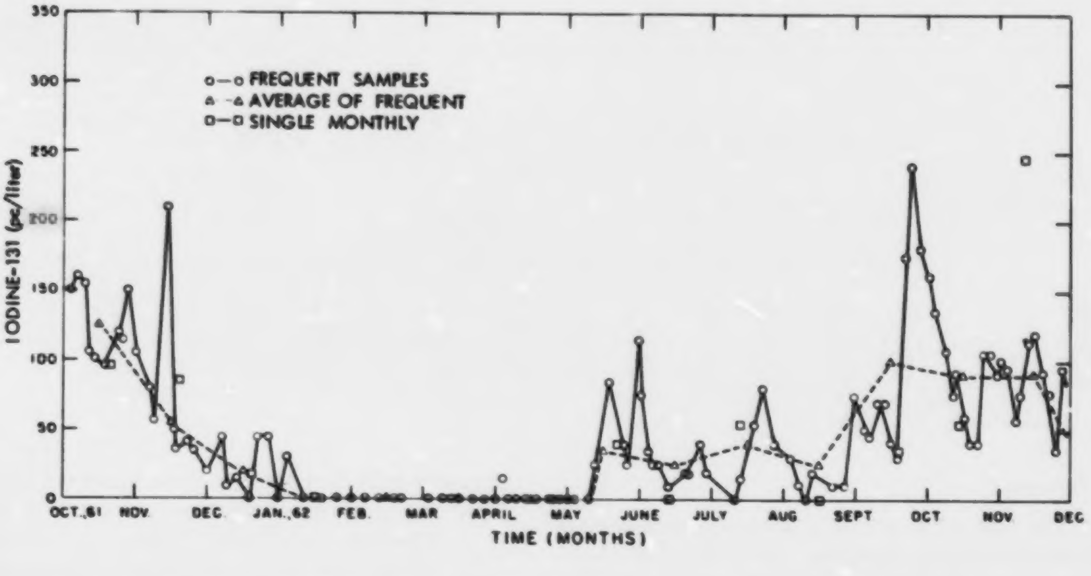

FIGURE 2.—INFLUENCE OF THE SAMPLING FREQUENCY ON THE OBSERVED IODINE-131 CONCENTRATIONS IN MILK (CINCINNATI, OHIO STATION)

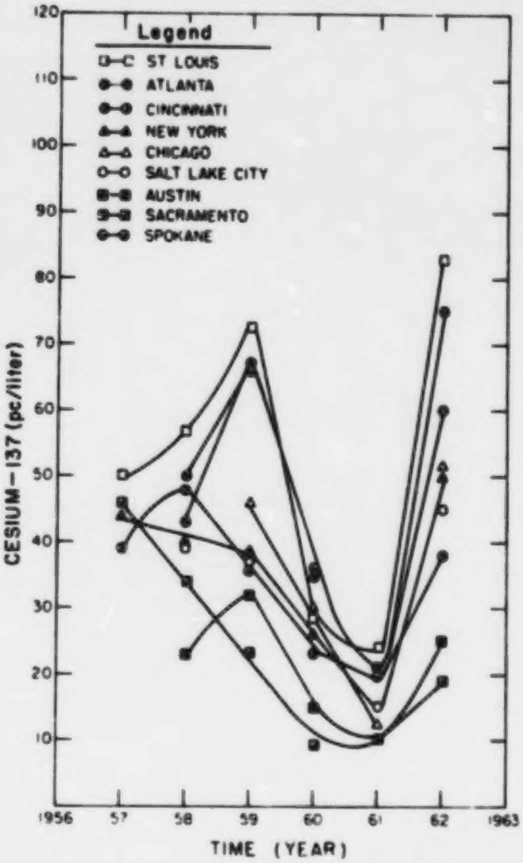

FIGURE 3.—PROFILE OF YEARLY AVERAGE CESIUM-137 CONCENTRATIONS IN MILK

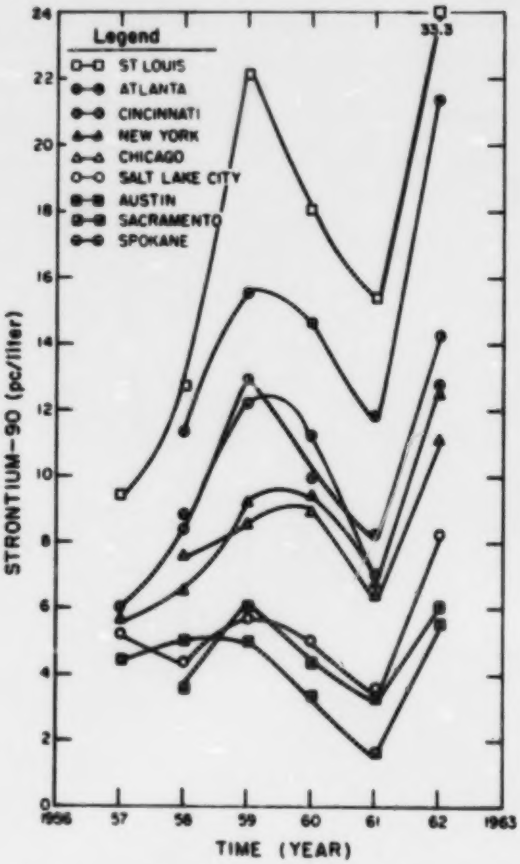

FIGURE 4.—PROFILE OF YEARLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN MILK

TABLE 10.—MAXIMUM VALUE, MEDIAN VALUE, AND MINIMUM VALUE OF THE MONTHLY RADIONUCLIDE AVERAGES FROM THE RAW MILK NETWORK, 1957–1962

[pc/liter]

Year	Iodine-131			Barium-140			Strontium-89			Strontium-90			Cesium-137		
	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.
1957[a]	990	205	<10	530	45	<10	360	85	15	12.9	5.3	1.5	155	45	20
1958	625	20	<10	230	<10	<10	485	60	<5	20.1	7.0	1.4	90	45	15
1959	20	<10	<10	14	<10	<10	280	10	<5	37.3	9.3	1.0	160	45	5
1960	<10	<10	<10	<10	<10	<10	<5	<5	<5	23.4	9.0	1.7	65	20	5
1961	330	<10	<10	75	<10	<10	170	<5	<5	23.0	6.4	1.0	35	15	<5
1962	535	<10	<10	165	<10	<10	335	25	<5	45.6	13.6	1.6	180	45	<5

[a] Six months data.

Summary

The raw milk sampling program, consisting of nine sampling stations located at New York City, Cincinnati, St. Louis, Sacramento, Salt Lake City, Atlanta, Austin, Chicago and Spokane has been in operation since 1957–58. Monthly milk samples from the milkshed serving these cities were analyzed for calcium and potassium content, I^{131}, Ba^{140}, Cs^{137}, Sr^{89} and Sr^{90}. These milk samples thus collected represent 1 or 2 days of production rather than a composite of all the milk produced from one sampling period to the next.

This sampling procedure has proved satisfactory for Sr^{90} and Cs^{137} and unsatisfactory for I^{131}, Ba^{140} and Sr^{89}, which was confirmed during October-November 1961 when the frequency of sampling was increased in all the nine locations. Analysis of single monthly samples and composites of daily milks showed no significant differences for Sr^{90} and Cs^{137}. Extension of this study in the Cincinnati area to a period of relatively rapid change (April to September 1962) of Sr^{90} in milk showed also that results between composited and single monthly samples are comparable within 25–50 per cent. However, during periods of rapid change in Sr^{90}, the time of collection of single monthly samples becomes important. Samples collected either at the beginning or end of the month may vary in Sr^{90} concentration by as much as 25 to 75 per cent.

In contrast to Sr^{90} and Cs^{137}, single monthly observations made for I^{131}, Ba^{140} and Sr^{89} do not represent the actual level during the intervening period and suggests daily sampling to obtain accurate estimates.

The Sr^{90} concentrations of milk samples from the raw milk and pasteurized milk networks serving the nine cities were compared over a period of 26 months. Statistical analysis of the data indicated good correlation between the raw and pasteurized milks except for those from Sacramento. This is possibly due to low Sr^{90} levels in the Sacramento area which showed relatively little change with time and errors involved in determining low levels of Sr^{90}. Based on a paired 't' test it is suggested that except for St. Louis and Atlanta, the Sr^{90} results from the raw milk network may be used in place of pasteurized milk for the time period not covered by the pasteurized milk network.

Profiles of yearly average Sr^{90} and Cs ^{137} concentrations in raw milk are presented to show the similiarity among the widely separated geographical areas in the trend of concentrations of these fission products in milk.

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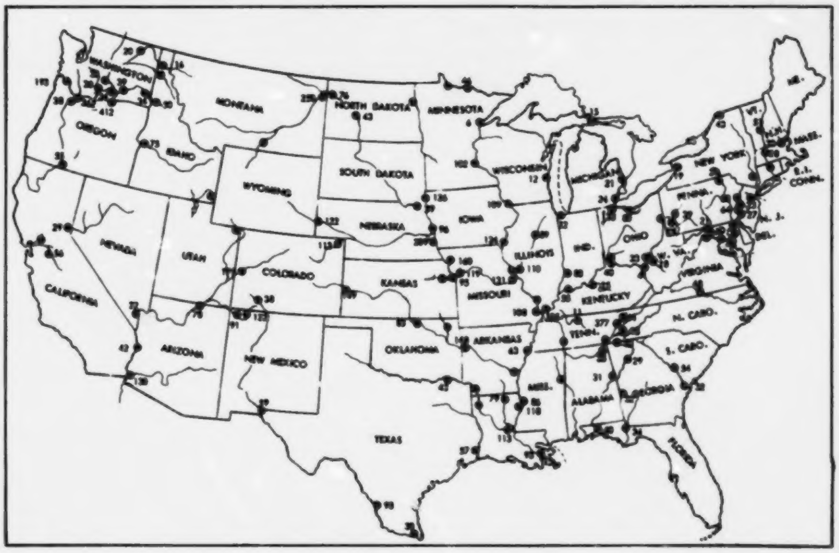
SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
April 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this Network has expanded to 126 stations as of August 1963 (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically and radiologically. These data can be used for evaluating sources of radioactivity which may effect domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).


WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEW YORK
VT.
N.H.
ME.
MASS.
R.I.
CONN.
PENNA.
N.J.
DEL.
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
IND.
OHIO
W. VA.
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KENTUCKY
CALIFORNIA
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TENN.
N. CARO.
S. CARO.
GEORGIA
ALABAMA
MISS.
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK STATIONS, APRIL 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS,[a] APRIL 1963—Continued

[Average concentrations in pc/liter]

Station	Beta activity: Suspended	Beta activity: Dissolved	Beta activity: Total	Alpha activity: Suspended	Alpha activity: Dissolved	Alpha activity: Total
Allegheny River: Pittsburgh, Pa	21	18	39	1	0	1
Animas River: Cedar Hill, N. Mex	90	32	122	13	1	14
Apalachicola River: Chattahoochee, Fla	15	19	34	0	0	0
Arkansas River						
Coolidge, Kans	35	114	149	<1	26	26
Ponca City, Okla	25	58	83	0	0	0
Fort Smith, Ark	72	76	148	6	0	6
Big Sioux River: Sioux Falls, S. Dak	39	87	126	2	5	7
Chattahooche River						
Atlanta, Ga	18	11	29	0	0	0
Columbus, Ga	14	18	32	0	0	0
Lanett, Ala	18	13	31	0	0	0
Clearwater River: Lewiston, Idaho	26	24	50	0	0	0
Clinch River						
Clinton, Tenn	17	27	44	0	<1	<1
Kingston, Tenn	123	254	377	1	0	1
Colorado River						
Loma, Colo	102	76	178	8	6	14
Page, Ariz	8	70	78	1	9	10
Boulder City, Nev	2	20	22	0	3	3
Parker Dam, Calif-Ariz	1	41	42	1	9	10
Yuma, Ariz	1	129	130	0	1	1
Columbia River						
Northport, Wash	5	15	20	0	0	0
Wenatchee, Wash	12	20	32	0	1	1
Pasco, Wash	131	605	736	—[b]	—	—
McNary Dam, Ore	75	337	412	0	1	1
Bonneville, Ore	49	313	362	0	0	0
Clatskanie, Ore	72	121	193	<1	0	<1
Cumberland River: Clarksville, Tenn	2	9	11	0	0	0
Connecticut River						
Wilder, Vt	19	32	51	0	1	1
Northfield, Mass	8	20	28	0	0	0
Cuyahoga River: Cleveland, Ohio	8	72	80	1	2	3
Delaware River						
Martins Creek, Pa	5	18	23	0	0	0
Trenton, New Jersey	12	11	23	0	0	0
Philadelphia, Pa	42	22	64	1	1	2
Escambia River: Century, Florida	18	22	40	0	0	0
Great Lakes						
Duluth, Minn	0	6	6	0	0	0
Sault Ste. Marie, Mich	4	11	15	0	0	0
Milwaukee, Wisc	2	10	12	0	1	1
Gary, Ind	5	17	22	0	0	0
Port Huron, Mich	7	14	21	0	0	0
Detroit, Mich	6	18	24	0	1	1
Buffalo, New York	4	15	19	0	0	0
Illinois River: Peoria, Ill	36	53	89	2	0	2
Kanawha River: Winfield Dam, W. Va	13	15	28	1	0	1
Klamath River: Keno, Oreg	27	28	55	0	0	0
Maumee River: Toledo, Ohio	46	87	133	1	1	2
Merrimack River: Lowell, Mass	9	24	33	0	1	1
Mississippi River						
St. Paul, Minn	34	68	102	0	2	2
Dubuque, Iowa	50	59	109	0	0	0
Burlington, Iowa	72	62	134	1	2	3
E. St. Louis, Ill	56	54	110	0	1	1
Cape Girardeau, Mo	47	61	108	2	2	4
W. Memphis, Ark	27	36	63	1	2	3
Vicksburg, Miss	54	32	86	1	0	1
Delta, La	79	39	118	1	0	1
New Orleans, La	58	35	93	2	0	2
Missouri River						
Williston, N. Dak	34	42	76	3	8	11
Bismarck, N. Dak	15	28	43	0	6	6
Yankton, S. Dak	25	34	59	2	5	7
Omaha, Nebr	60	36	96	7	6	13
Missouri River—Cont.						
St. Joseph, Mo	124	36	160	16	2	18
Kansas City, Kans	56	39	95	6	5	11
Missouri City, Mo	79	40	119	9	2	11
St. Louis, Mo	99	32	131	14	2	16
Monongahela River: Pittsburgh, Pa	0	29	29	0	1	1
North Platte River: Henry, Nebr	32	90	122	1	27	28
Ohio River						
Addison, Ohio	11	22	33	0	0	0
Huntington, W. Va	20	21	41	1	0	1
Cincinnati, Ohio	23	17	40	1	0	1
Louisville, Ky	10	15	25	0	0	0
Evansville, Ind	30	25	55	2	1	3
Cairo, Ill	63	42	105	6	<1	6
Ouchita River: Bastrop, La	30	49	79	0	1	1
Pend Oreille River: Albeni Falls Dam, Idaho	5	11	16	0	0	0
Platte River: Plattsmouth, Nebr	127	82	209	6	4	10
Potomac River						
Williamsport, Md	7	14	21	0	0	0
Great Falls, Md	18	18	36	1	0	1
Rainy River: International Fls, Minn	10	36	46	0	0	0
Red River, South						
Denison, Tex	0	43	43	0	5	5
Alexandria, La	66	47	113	2	1	3
Rio Grande River						
Alamosa, Colo	20	18	38	0	2	2
El Paso, Tex	25	34	59	2	3	5
Laredo, Tex	44	49	93	0	2	2
Brownsville, Tex	5	25	30	1	0	1
Roanoke River: John H. Kerr Resr. & Dam, Va	30	18	48	2	0	2
Sabine River: Ruliff, Tex	26	31	57	0	0	0
San Joaquin River: Vernalis, Calif	31	25	56	1	0	1
San Juan River: Shiprock, N. Mex	47	44	91	6	4	10
St. Lawrence River: Massena, N. Y	17	26	43	0	0	0
Schuylkill River: Philadelphia, Pa	13	14	27	0	0	0
Savannah River						
North Augusta, Ga	30	24	54	1	0	1
Port Wentworth, Ga	12	20	32	—	—	—
Ship Creek: Anchorage, Alaska	13	33	46	0	0	0
Snake River						
Ice Harbor Dam, Wash	9	25	34	0	0	0
Wawawai, Wash	17	22	39	0	0	0
Payette, Idaho	47	28	75	0	2	2
South Platte River: Julesburg, Colo	13	99	112	1	22	23
Susquehanna River						
Sayre, Pa	13	15	28	0	0	0
Conowingo, Md	9	10	19	0	0	0
Tennessee River						
Lenoir City, Tenn	17	18	35	0	1	1
Chattanooga, Tenn	10	33	43	1	2	3
Bridgeport, Ala	10	25	35	0	0	0
Truckee River: Farad, Calif	9	20	29	0	0	0
Wabash River: New Harmony, Ind	30	53	83	1	1	2
Willamette River: Portland, Oreg	22	16	38	0	0	0
Yakima River: Richland, Wash	12	14	26	0	1	1
Yellowstone River: Sidney, Mont	197	53	250	13	3	16
Maximum	197	605	736	16	27	28
Minimum	1	6	6	0	0	0

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[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data* (6).

[b] Dashes indicate data not available.

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A one-liter "grab" sample is collected weekly by personnel of the participating agencies and shipped to the PHS Robert A. Taft Sanitary Engineering Center Laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid evaluation of fallout effects from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Since that time, a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents April 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of this report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved-solids in raw water collected at that station. Network results for the years 1957-1962 have been summarized by Weaver *et al* (9).

REFERENCES

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(*3*) Ibid., 1960 Edition.

(*4*) Ibid., 1961 Edition.

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(*8*) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U.S. Atomic Energy Commission, New York Operations Office (1962).

(*9*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data*, 4:306-16, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

SECTION IV.—OTHER DATA

In Vitro Measurement of Iodine-131 in Bovine Thyroids

Kenneth H. Falter,[1] *George Murray,*[2] *Jesse P. Walker,*[3] *and Arthur H. Wolff*[4]

This program was undertaken to supplement existing environmental radiation surveillance data by collecting and analyzing bovine thyroids for iodine-131. Iodine-131 concentrations in bovine thyroids reflect the levels of contamination that exist on the pasture in which the animal grazed or in its feed. Should a rise in environmental iodine-131 levels occur, this study will help to delineate the specific milksheds, counties, and farms at which the rise has taken place.

When enough data are available an attempt will be made to develop a mathematical model relating iodine-131 concentrations in the bovine thyroid to iodine-131 concentrations in milk. It might then be possible to retrospectively estimate I^{131} levels in milk for that period, 1952–1957, when bovine thyroids were analyzed for I^{131} but milk was not.

Previous studies have demonstrated a rise in iodine-131 levels in animal thyroid glands following nuclear weapons tests (*1–6*), and it has been suggested that continuous monitoring of thyroid glands from slaughter cattle will provide a good index of the biological concentration of air-borne radioactive fallout (*7*). It has also been stated that the magnitude and pattern with time of radioactivity levels in the thyroid are of interest because (i) there is provided an alert to any build-up of potentially hazardous levels, (ii) as relationships are developed, radioiodine measurements could serve as a sensitive monitoring system for other fallout nuclides less easily detectable, and (iii) information may be obtained on the movement of radioiodine in the biological system. (*2*)

Background

This program, conducted by the Division of Radiological Health, Public Health Service, in cooperation with the Meat Inspection Division, U.S. Department of Agriculture, began in September 1962 on a pilot scale. Des Moines, Iowa and Salt Lake City, Utah were selected as the initial collection points. In October 1962, Seattle, Washington was added as the third collection point. By the end of January 1963, the methods of collection and analysis for I^{131} in the bovine

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thyroid were established and the program became operational.

Specimens are collected from those dairy cows coming to slaughter which are either brucellosis or tuberculosis reactors. A history of each animal is readily available at the time of slaughter. According to regulation, once a cow is identified as having brucellosis or tuberculosis, it must be slaughtered within ten days; in many instances, slaughter actually takes place within two or three days. The time factor is important, as the effective half-life of I^{131} in the cow's thyroid is about seven days. (4)

In April 1963, the collection program was expanded to include those areas where cows are on pasture all year and where many brucellosis and tuberculosis reactors come to slaughter. Collection points were added at Montgomery, Alabama; Atlanta, Georgia; New Orleans, Louisiana; Jackson, Mississippi; Oklahoma City, Oklahoma; and Dallas-Fort Worth, Texas.

Sample Collection

Locations which are in the Public Health Service pasteurized milk network are selected as collection points in order to obtain comparable data for I^{131} in milk and in bovine thyroids. Milksheds have been identified by county from data collected by the Division of Environmental Engineering and Food Protection, USPHS. Those milksheds of particular interest are identified, and the Meat Inspection Division, Agricultural Research Service, USDA, is then notified. Meat inspectors in the areas of interest are asked to collect thyroid specimens from brucellosis and tuberculosis reactors coming to slaughter in their area, and to provide, with each sample, information giving the county of origin of the animal, age of the cow, weight and/or breed, date of slaughter and whether or not the cow was lactating at the time of slaughter.

Glass vials containing a small quantity of paraformaldehyde are supplied to the collectors. Each specimen is placed in a vial and an information tag is filled out. The specimens are then mailed to the counting facility at Beltsville, Maryland where they are handled by Division of Radiological Health personnel assigned to the Beltsville facility. The thyroids are counted for I^{131} activity, determined from the 0.36 Mev gamma emission, on one of two single-channel gamma spectrometers, using a scintillation well detector containing a three-inch diameter NaI (Tl) crystal. Each counter has an automatic sample changer which handles 50 samples at a time. The glass collection vials are compatible with this system, so that when specimens are received, the vials are attached to the sample changer and the specimens are counted automatically. A system such as this provides for constant geometry of each glass vial in the well of the crystal, and also minimizes the possibility of samples getting mixed up in handling.

In these gamma spectrometers the efficiency of counting varies with the volume of the sample in the glass vial, and the spectrometers have, therefore, been calibrated for graduated volumes ranging from 1 ml to 25 ml, the capacity of the vial. For these volumes, the counting efficiency ranges from 15 to 25 percent. Before each vial is placed on the sample changer, the volume of the thyroid in the vial is measured, so that the applicable counting efficiency is applied to each specimen. The thyroids are then weighed, and the activity calculated in picocuries of I^{131} per gram of thyroid, corrected to 12:00 noon of the day of slaughter.

Discussion of Data

Between January 20 and June 29, 1963, 760 thyroid specimens were collected and analyzed for iodine-131 activity. Of these, 427 were from cows which were lactating at the time of slaughter and 333 were from nonlactating cows. A cow is considered to be either from a milkshed area or a non-milkshed area, depending on whether or not it grazed in a county which is in one of the milkshed areas of the PHS pasteurized milk network. The counties from which samples have been received are indicated in figure 1. Those counties in black are in one of the 18 milksheds and those shaded in lie outside the milkshed areas.

The data for all samples collected between January 20 and June 29 are summarized and tabulated in table 1. The data have been classified according to four groupings: milkshed and non-milkshed areas, and lactating and nonlactating cows. The weekly average is the arithmetic mean for the given number of thyroids from cows slaughtered that week. The minimum and maximum values for the week are also shown, along with their two sigma (2σ) or 95% counting error. This counting error is an indication of the inherent statistical variation associated with all measurements of radionuclide concentrations. The concentration ±95% C.E. is the range within which the true concentration is expected to fall 95 percent

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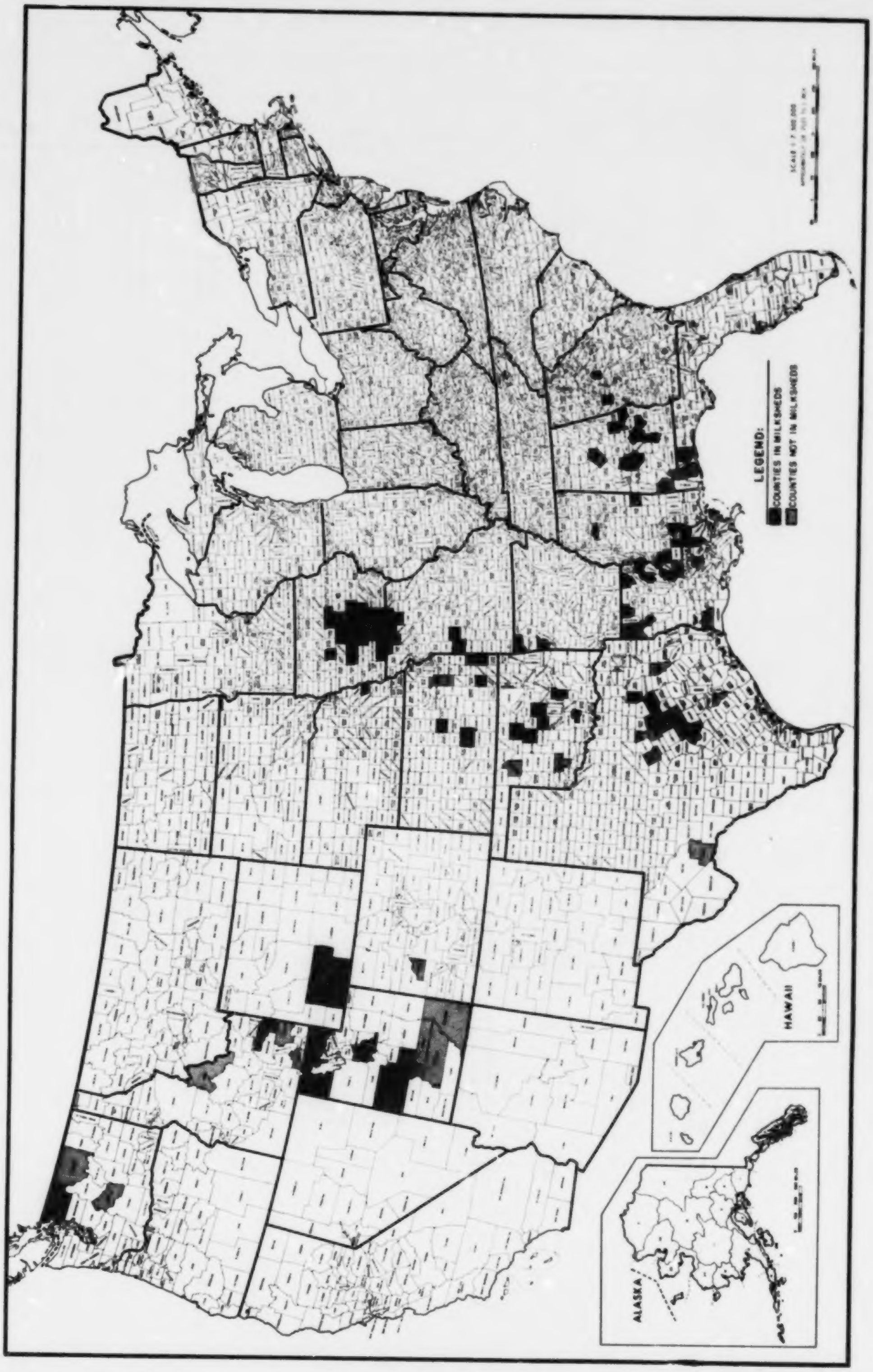
LEGEND:
■ COUNTIES IN MILKSHEDS
▨ COUNTIES NOT IN MILKSHEDS
HAWAII
ALASKA

FIGURE 1—SAMPLE COLLECTION AREAS IN THE BOVINE THYROID COLLECTION PROGRAM

TABLE 1.—IODINE-131 IN BOVINE THYROIDS, 1963

[pc/g of thyroid]

	Lactating						Nonlactating					
	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number
Alabama												
Montgomery												
Week of 4/14	4.7	2.6	•2.6	6.4	2.6	4						
4/21	2.6	2.0	1.0	3.2	1.0	5	3.6	3.5	1.2	3.6	1.2	2
4/28	1.3	1.1	•1.3	1.6	1.1	3	2.0	1.0	•1.0	2.5	2.4	6
5/5	2.1	1.1	0.8	4.3	•4.6	5	0.8	0.0	•0.9	1.5	0.5	4
5/12	1.8	0.9	•1.3	2.8	0.8	6	1.2	0.0	•1.4	2.7	0.9	7
5/19	1.8	1.4	•1.8	2.1	1.8	3	0.8	0.0	•2.3	1.9	1.1	7
5/26	1.2	1.2	0.6	1.2	0.6	1	1.2	0.9	•0.9	3.0	1.1	17
6/2							0.5	0.3	•0.5	0.5	0.6	5
6/9	0.7	0.7	0.7	0.7	0.7	1	1.0	0.3	•1.0	2.0	1.2	16
Non-Milkshed												
Week of 4/14	6.0	3.3	0.7	8.6	1.6	2	1.6	1.6	1.4	1.6	1.4	1
4/21	2.6	2.6	1.5	2.6	1.5	1						
5/5	0.6	0.6	•0.5	0.6	•0.8	1	2.4	2.4	1.0	2.4	1.0	1
5/12	0.2	0.2	•1.3	0.2	•1.3	1						
5/19	0.9	0.4	•1.0	1.3	•1.4	5						
5/26							1.0	0.6	•0.7	1.6	0.7	7
Arkansas												
Little Rock												
Week of 4/21	2.8	2.8	1.8	2.8	1.8	1						
6/9	1.4	1.4	1.2	1.4	1.2	1						
6/23	1.3	1.3	•1.6	1.3	•1.6	1						
Non-Milkshed												
Week of 4/21	3.1	2.2	0.8	4.8	1.9	3						
6/23	0.3	0.0	•1.7	0.8	•2.6	4						
Colorado												
Non-Milkshed												
Week of 1/20							0.0	0.0	•8.7	0.0	•72.3	5
6/2							0.6	0.5	•0.7	0.6	0.6	2
Georgia												
Atlanta												
Week of 4/28							2.5	2.0	0.8	3.1	0.6	4
5/12	1.2	0.4	•1.8	1.6	1.2	4	1.9	1.9	1.8	1.9	1.6	1
6/2	1.6	1.6	0.5	1.6	0.5	1	1.6	0.9	0.8	1.9	0.5	4
Non-Milkshed												
Week of 4/28	3.4	1.0	0.5	5.7	0.6	3	3.5	1.6	0.6	5.4	1.2	2
6/2	1.7	1.6	0.6	1.8	0.8	2						
Idaho												
Non-Milkshed												
Week of 1/20							10.6	0.0	•20.4	26.1	10.7	3
3/17							0.0	0.0	•0.9	0.0	•0.9	1
5/19	0.5	0.5	•0.8	0.6	0.5	2	0.4	0.0	•1.2	0.4	•0.9	3
Iowa												
Des Moines												
Week of 1/20	201.9	201.9	44.4	201.9	44.4	1	29.1	23.8	20.0	34.4	17.4	2
1/27							12.9	0.0	•3.5	25.8	9.1	2
2/3							22.4	4.7	3.2	48.4	11.0	5
2/10	57.2	35.9	4.1	99.3	7.8	7	76.4	3.9	1.9	150.1	11.4	8
2/17	32.2	32.2	6.7	32.2	6.7	1	79.8	0.0	•5.7	159.5	12.8	2
2/24	20.2	0.0	•5.8	73.4	7.1	4	31.4	2.9	1.0	378.3	26.3	13
3/3	12.5	3.9	2.5	27.8	4.9	3	14.1	0.8	•1.9	34.6	3.2	4
3/10	5.9	0.4	•0.7	25.9	2.0	5	20.1	19.4	1.6	20.7	1.8	2
3/17	10.6	0.7	0.1	24.3	2.1	3	1.1	1.1	•1.1	1.1	0.7	2
3/24	2.9	0.0	•0.8	6.4	2.0	5	19.3	0.0	•2.4	30.7	3.1	9
3/31	1.7	0.0	•1.6	3.3	2.4	6	4.7	0.0	•2.2	23.1	2.9	6
4/7	0.8	0.5	•1.4	1.0	0.5	3	5.7	3.7	1.6	8.1	1.1	4
4/14							2.9	2.9	1.0	2.9	1.0	1
4/21	0.8	0.0	•4.0	6.2	0.6	9	0.4	0.2	•0.5	0.5	•0.8	3
5/5	1.6	0.4	•0.7	1.7	•1.8	4						
5/12	1.0	0.3	•0.8	1.8	1.4	4	1.2	1.2	0.8	1.2	0.8	1
5/19	1.7	0.7	•0.7	2.7	0.7	9	1.6	1.6	0.5	1.6	0.7	2
5/26	2.1	0.8	0.5	3.4	2.4	6	2.3	2.3	0.8	2.3	0.8	1
6/2	2.1	0.6	0.3	3.6	1.8	2	1.2	0.9	0.4	1.7	1.5	5
6/9	2.1	1.6	0.8	2.5	0.9	3	1.2	0.7	0.3	2.1	1.1	8
6/16	2.2	2.1	1.1	2.3	1.0	2	2.6	1.3	0.6	4.1	1.6	3
6/23	0.8	0.0	•2.6	2.3	1.6	5	0.4	0.0	•1.7	0.8	•1.5	5
Non-Milkshed												
Week of 3/10	1.6	1.6	1.2	1.6	1.2	1						
6/2	1.4	0.5	0.2	2.2	0.7	4	0.9	0.5	0.3	1.5	0.4	12
Kansas												
Wichita												
Week of 4/21							0.5	0.3	•0.3	0.8	0.5	2
4/28	2.7	2.7	0.7	2.7	0.7	1						
5/29	0.5	0.3	•0.5	0.6	0.4	2						
Non-Milkshed												
Week of 2/17							12.0	12.0	10.6	12.0	10.6	1
4/14							8.7	8.7	0.8	8.7	0.8	1
4/21							0.7	0.7	0.5	0.7	0.5	1
5/5							0.9	0.9	0.7	0.9	0.7	1

• Indicates that the 95 percent counting error is equal to or greater than the value itself.

TABLE 1.—IODINE-131 IN BOVINE THYROIDS, 1963—Continued

[pc/g of thyroid]

	Lactating						Nonlactating					
	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number
Louisiana												
New Orleans												
Week of 4/28	0.8	0.5	*0.8	1.4	0.8	3	0.6	0.0	*3.4	1.2	1.0	2
6/2	1.1	1.0	0.6	1.3	1.2	3						
6/16	0.2	0.0	*1.0	0.5	0.4	2						
6/23	0.3	0.2	*0.6	0.4	*0.8	3						
Non-Milkshed												
Week of 4/21	3.0	1.9	*2.4	5.0	1.0	5	2.7	0.3	*1.0	5.1	0.8	7
4/28	0.6	0.0	*5.1	3.4	1.1	4	0.2	0.0	*3.8	0.3	*7.3	2
5/5	2.4	2.0	1.0	2.9	1.0	4	2.0	1.1	0.9	3.6	0.8	4
5/12	6.5	4.6	2.6	7.7	5.4	3	0.7	0.7	*3.4	0.7	*3.9	2
5/19	1.1	0.6	0.8	1.5	0.9	8	0.8	0.7	0.6	0.8	0.7	2
5/26	1.1	0.9	0.8	1.6	1.3	4	1.2	0.9	0.9	1.4	0.9	3
6/2	1.1	0.7	0.5	1.7	1.0	6						
6/9	0.8	0.5	*0.6	0.9	0.7	3	0.7	0.4	*0.5	0.9	0.6	2
6/16	0.8	0.7	0.7	0.9	0.8	2	0.7	0.6	*0.6	0.8	0.6	2
6/23	0.7	0.1	*0.7	2.1	0.7	4	0.7	0.2	*0.4	1.2	*1.4	2
Mississippi												
Jackson												
Week of 4/28	0.8	0.5	*0.8	1.4	0.8	3	1.2	1.2	1.0	1.2	1.0	1
5/26	1.0	0.6	0.7	1.5	1.2	9	0.8	0.8	0.8	0.9	0.7	3
6/2	1.1	1.0	0.6	1.3	1.2	3						
6/16	0.5	0.0	*1.0	0.9	0.6	3	0.5	0.5	*0.6	0.5	*0.6	1
6/23	0.5	0.2	*0.6	1.0	0.6	6	0.0	0.0	*1.2	0.0	*1.2	1
Non-Milkshed												
Week of 4/21	4.1	3.9	0.8	4.4	0.9	2	3.8	3.8	1.2	3.8	1.2	1
4/28	1.4	1.0	0.8	1.8	0.7	4	1.7	1.7	0.9	1.7	0.9	1
5/5	1.8	1.1	0.6	2.4	0.8	2						
5/12	0.2	0.2	1.4	0.2	1.4	1						
5/26							0.8	0.8	*1.0	0.8	*1.0	1
6/2	0.8	0.8	*0.8	0.8	*0.8	1						
6/16	1.0	1.0	0.9	1.0	0.9	1						
6/23	0.2	0.1	*0.6	0.4	*1.0	2						
Missouri												
Kansas City												
Week of 1/20	14.8	14.8	8.9	14.8	8.9	1	85.2	61.0	17.2	109.3	24.9	2
1/27	52.3	52.3	12.9	52.3	12.9	1	144.4	107.3	22.9	168.8	32.7	3
2/3							119.0	119.0	2.3	119.0	2.3	1
2/10	43.2	43.2	4.6	43.2	4.6	1	65.7	65.7	6.4	65.7	6.4	1
2/17	0.0	0.0	*41.6	0.0	*41.6	1	98.4	37.4	8.5	159.5	12.8	2
3/10	39.9	39.9	4.2	39.9	4.2	1						
3/17	6.4	4.6	1.9	8.1	2.7	2	17.6	2.6	1.4	41.3	4.5	5
3/24	6.4	6.4	2.0	6.4	2.0	1	8.0	2.6	1.2	18.1	2.1	3
3/31	0.0	0.0	*1.4	0.0	*1.4	1	0.8	0.0	*1.6	2.5	1.8	3
4/7							13.6	7.8	0.9	24.9	2.2	3
4/28	1.7	0.7	0.6	3.6	1.2	8	3.1	3.1	1.1	3.1	1.1	1
5/26	1.6	1.0	0.7	1.9	0.7	4	1.9	1.9	0.8	1.9	0.8	1
6/2	2.3	2.3	0.4	2.3	0.4	1	1.3	1.3	0.3	1.3	0.3	1
6/9	1.1	1.0	0.7	1.2	0.6	2						
6/16	0.6	0.6	*1.5	0.7	*1.8	2						
6/23	0.4	0.3	*0.6	0.6	*1.6	2						
St. Louis												
Week of 3/24	6.4	6.4	2.0	6.4	2.0	1	3.4	3.4	1.3	3.4	1.3	1
5/26	7.5	7.5	3.8	7.5	3.8	1						
Non-Milkshed												
Week of 4/7	3.4	3.4	1.0	3.4	1.0	1	3.7	3.7	0.8	3.7	0.8	1
5/26	0.8	0.8	0.7	0.9	0.9	2						
Oklahoma												
Oklahoma City												
Week of 4/14	2.0	0.6	*1.1	3.2	1.1	7	2.5	2.4	0.9	2.6	0.9	2
4/21	0.9	0.3	*0.4	1.5	0.5	4	1.6	1.6	0.6	1.6	0.6	1
4/28	2.4	2.4	1.0	2.4	1.0	1						
5/5	2.8	0.9	0.5	6.2	1.6	4	2.3	2.1	0.6	2.4	1.4	2
5/12	0.4	0.0	*1.3	0.8	*1.2	5						
5/19	0.8	0.4	*0.6	1.5	1.4	9	0.5	0.2	*0.5	0.8	0.7	4
5/26	1.2	0.6	0.5	1.6	0.9	5	1.4	1.2	0.7	1.5	0.6	4
6/2	1.1	0.8	*0.8	2.0	1.1	6	1.2	1.2	0.6	1.2	0.6	1
6/9	1.8	0.6	*0.7	4.2	1.7	12	0.9	0.6	*0.8	1.2	0.8	2
6/16	0.8	0.8	0.4	0.9	0.3	2						
6/23	0.4	0.0	*1.5	0.8	*3.0	2						
Non-Milkshed												
Week of 5/5	1.8	1.8	*1.8	1.8	*1.8	1	0.9	0.6	*0.6	1.2	0.7	3
5/19	0.8	0.6	0.5	1.0	0.5	5	0.6	0.3	*0.6	0.8	0.6	5
5/26	0.5	0.5	*0.7	0.5	*0.7	1						
6/2	1.1	1.0	0.7	1.3	1.0	3						
6/9	1.3	0.2	*1.2	3.4	1.8	5	0.7	0.4	*0.8	1.0	0.9	6
6/16	1.0	0.6	0.4	1.3	0.6	3						
6/23	1.7	1.3	*2.5	2.1	*2.6	2						
Tennessee												
Memphis												
Week of 4/21	2.8	2.8	1.8	2.8	1.8	1						

* Indicates that the 95 percent counting error is equal to or greater than the value itself.

TABLE 1.—IODINE-131 IN BOVINE THYROIDS, 1963—Continued

[pc/g of thyroid]

	Lactating						Nonlactating					
	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number	Average	Minimum	95% C.E.	Maximum	95% C.E.	Number
Texas												
Austin												
Week of 4/14	2.6	1.0	0.8	5.1	1.2	3	5.0	5.0	1.2	5.0	1.2	1
5/5	1.7	1.0	0.7	2.7	1.1	3						
Dallas												
Week of 4/14	2.2	2.2	1.0	2.2	1.0	1						
4/28	1.6	1.2	1.1	2.3	1.5	3	1.6	1.4	•1.4	1.9	1.3	2
5/12	0.6	0.0	•7.3	0.1	•4.0	4						
5/19	0.7	0.0	•1.9	1.6	•2.1	4	0.3	0.3	•1.2	0.3	•1.2	1
5/26	1.0	0.3	•1.3	1.6	•2.1	4	0.6	0.6	•0.7	0.6	•0.7	1
6/2							0.7	0.7	•0.8	0.7	0.7	2
6/9	1.1	0.3	•0.8	2.5	1.0	5						
6/16	1.1	0.9	0.6	1.3	0.9	3	1.2	1.0	•1.1	1.3	1.0	2
6/23	0.2	0.0	•0.7	0.4	•3.9	4						
Non-Milkshed												
Week of 4/14	2.3	0.9	•1.3	3.3	1.3	3	5.4	3.7	1.2	7.2	1.0	2
4/21	1.7	0.5	•0.5	5.1	1.8	10	4.0	1.6	0.6	4.1	1.3	5
5/5							2.1	1.0	0.6	3.2	1.2	2
5/19	0.4	0.2	•0.4	0.7	•1.2	2	0.1	0.1	•0.1	0.1	•0.1	1
5/26	1.7	1.7	1.1	1.7	1.1	1						
Utah												
Salt Lake City												
Week of 1/20							37.6	37.6	11.2	37.6	11.2	1
1/27	6.0	6.0	•7.4	6.0	•7.4	1						
2/3	13.0	13.0	3.3	13.0	3.3	1	18.7	18.7	6.2	18.7	6.2	1
2/10	8.2	8.2	1.8	8.2	1.8	1						
2/17	6.5	6.5	1.1	6.5	1.1	1	27.4	15.5	2.1	39.2	4.1	2
2/24							7.1	7.1	3.3	7.1	3.3	1
3/3	1.4	1.1	•2.0	1.6	•2.1	2	0.0	0.0	•2.1	0.0	•2.2	2
3/31	0.4	0.4	•1.8	0.4	•1.8	1						
4/14	0.7	0.7	•1.1	0.7	•1.1	1						
4/28	0.0	0.0	•0.6	0.0	•0.6	1						
5/5	0.4	0.4	•0.5	0.4	•0.5	1						
5/12							0.4	0.4	•0.4	0.4	•0.4	1
5/19	0.0	0.0	•0.7	0.0	•0.7	1						
5/26	1.2	0.3	•0.4	1.7	0.8	4	1.1	0.9	0.8	1.2	1.7	2
6/16	0.5	0.5	0.3	0.5	0.3	1						
Non-Milkshed												
Week of 3/24	0.1	0.1	•0.4	0.1	•0.4	1						
3/31							13.1	13.1	1.5	13.1	1.5	1
4/7							1.1	1.1	•1.1	1.1	•1.1	1
4/28	0.4	0.4	•0.4	0.5	•0.5	2						
5/5							2.1	2.1	0.7	2.1	0.4	2
5/26	1.2	1.2	0.7	1.2	0.7	1						
6/9	1.0	1.0	0.7	1.1	0.7	2						
Washington												
Seattle												
Week of 1/13	0.0	0.0	•0.4	0.0	•0.4	1						
3/3							0.8	0.0	•2.3	2.4	•2.4	3
3/24							2.0	2.0	0.8	2.0	0.8	1
4/14	0.2	0.2	•0.6	0.2	•0.6	1						
5/12	0.0	0.0	•1.2	0.0	•1.2	1						
Non-Milkshed												
Week of 2/3	0.0	0.0	•3.6	0.0	•3.6	1	15.4	1.7	•4.0	29.0	8.3	2
Wyoming												
Laramie												
Week of 1/20							4.4	4.4	•7.3	4.4	•7.3	1

• Indicates that the 95 percent counting error is equal to or greater than the value itself.

of the time. Counting errors greater than or equal to the maximum or minimum value are indicated.

Weekly averages for selected areas have been graphically illustrated in figures 2–7. The solid line connects the averages for lactating cows and the dotted line connects the averages for nonlactating cows. The best estimate of the lower limit of detectability is one picocurie of I^{131} per gram of thyroid. This value has been determined for the smallest samples received which weighed about 3 g. For larger samples, the lower limit of detectability is less than 1.0 pc/g, but for uniformity of reporting, the 1.0 level will be used throughout. Weekly averages below this level are indicated.

The highest thyroid levels in this study were recorded during January and February 1963, when 15 specimens had I^{131} concentrations exceeding 100 pc/g, including three specimens having levels of 201.9, 240.1 and 378.3 pc/g. All of these thyroids were taken from cows in the Des Moines, Iowa or Kansas City, Missouri milksheds. The thyroid containing 201.9 pc/g of I^{131} came from a

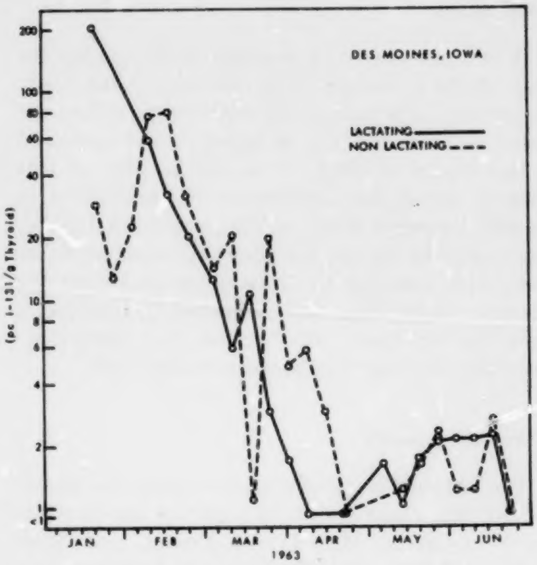

FIGURE 2.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE DES MOINES MILKSHED

cow which was lactating at the time of slaughter; the other 14 were all from nonlactating cows. These represent one-third of the specimens from nonlactating cows received from these areas during January and February. A weekly average (for three thyroids) of 144.4 pc/g was recorded for Kansas City for the week of January 27.

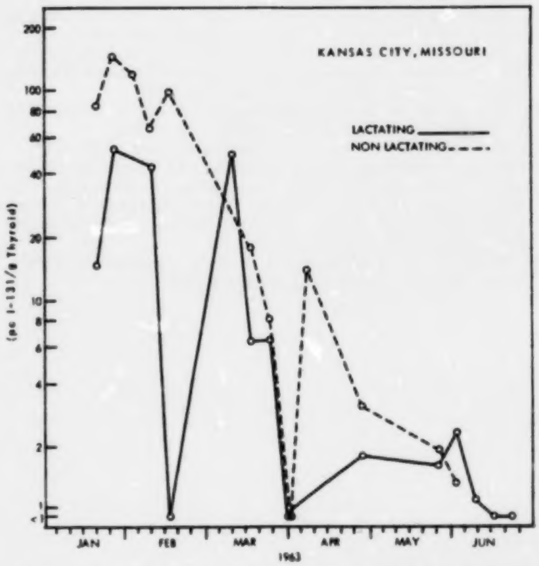

FIGURE 3.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE KANSAS CITY MILKSHED

Since April 1, all weekly averages but one have been below 10.0 pc/g. The exception is the Kansas City milkshed during the week of April 7 where the average (three thyroid specimens) reached 13.6 pc/g.

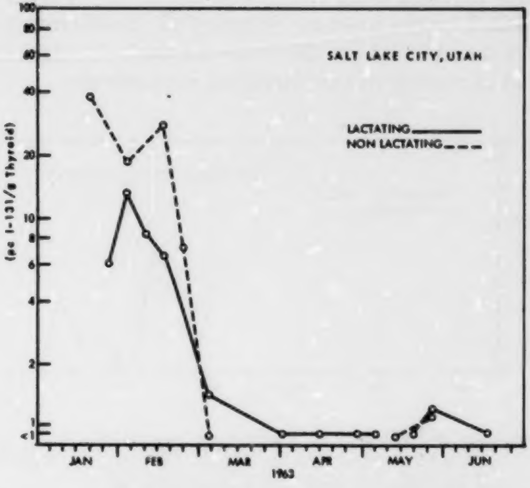

FIGURE 4.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE SALT LAKE CITY MILKSHED

Since May 1, all weekly milkshed averages but one have been below 3.0 pc/g. The exception is the St. Louis, Missouri milkshed during the week of May 26 with a value of 7.5 pc/g (one thyroid specimen).

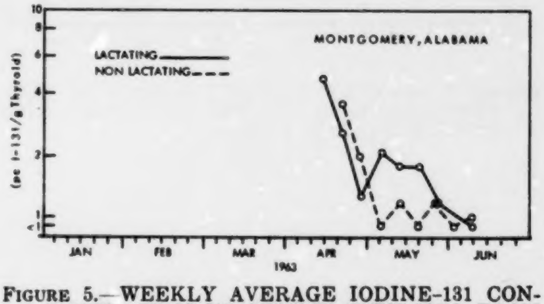

FIGURE 5.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE MONTGOMERY MILKSHED

For levels of activity above 10.0 pc/g, the weekly averages for nonlactating cows were higher than the averages for lactating cows, with one exception —Des Moines, Iowa during the week of January 20.

An interesting point is the ratio of maximum to minimum values for a given week. In previous studies, ratios as high as 10:1 (*1–4*) and 30:1 (*5*) have been reported for cows slaughtered on the same day. Values reported in this study are for specimens collected over one week's time, and for comparability with the studies cited, ratios may have to be reduced by a factor of two due to radioactive decay. The highest ratios have been for thyroids from the Des Moines area. They are 160:0 for the week of February 17 (nonlactating), 73:0 and 378:3 (or 126:1) for the week of February 24 (lactating and nonlactating, respectively).

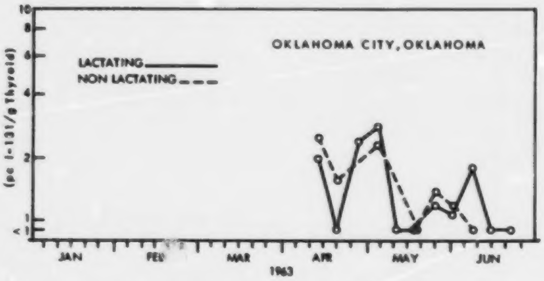

FIGURE 6.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE OKLAHOMA CITY MILKSHED

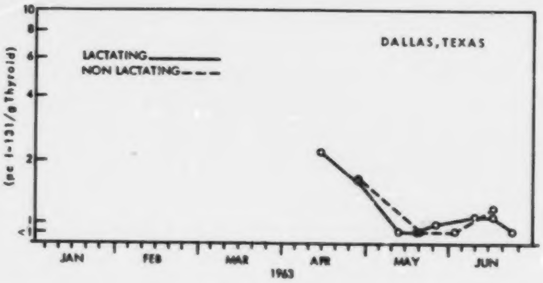

FIGURE 7.—WEEKLY AVERAGE IODINE-131 CONCENTRATION IN BOVINE THYROIDS FROM THE DALLAS MILKSHED

Conclusions

It is apparent, from looking at the graphs for Des Moines, Kansas City and Salt Lake City, that some of the earliest reported values reflect the decaying of iodine-131 in fallout which occurred in the winter of 1962. It is not possible at this time to assess the significance of fluctuations in weekly averages from <1.0 pc/g to 3.0 pc/g. They may be caused by counting error alone or there may actually be trace levels of I^{131} on the pasture. More data will be needed to establish a base line for each milkshed so that deviations from this base line may be easily recognized.

Acknowledgements

The authors gratefully acknowledge the assistance of Mr. Dean Steiner in counting the thyroids for I^{131} activity, Mrs. Louise French and Miss Patricia Bryan in calculating, tabulating and charting the thyroid values and the USDA meat inspectors in the milksheds who have cooperated by supplying the thyroid specimens.

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Lawrence Radiation Laboratory sites.

LAWRENCE RADIATION LABORATORY
Calendar Year 1962

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory is located to the east of the campus of the University of California (see figure 1). Technical facilities include a 6.3 Bev proton accelerator (Bevatron), a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, and various chemistry physics laboratories. The Bevatron, the largest source of radiation at the boundaries, was not in operation during the second half of 1962. Due to high humidity and water leaks, the electronic counting equipment was removed from the environmental monitoring stations.

The environmental sampling program includes monitoring of the atmosphere, water and rain or dry deposition. Three types of atmospheric sample are taken: stack samples, local area samples and perimeter samples. Data for these are shown in table 1.

TABLE 1.—ATMOSPHERIC MONITORING, BERKELEY SITE—1962

[Average concentrations in pc/m³]

Sampling locations	Total number of samples	First half		Second half	
		Alpha	Beta	Alpha	Beta
Stacks	2079	0.008	3.86	0.007	2.13
Local area	312	0.000	4.44	0.000	4.82
Perimeter	194	0.001	5.77	0.001	4.84
Reference sample	50	0.001	4.26	0.000	3.49

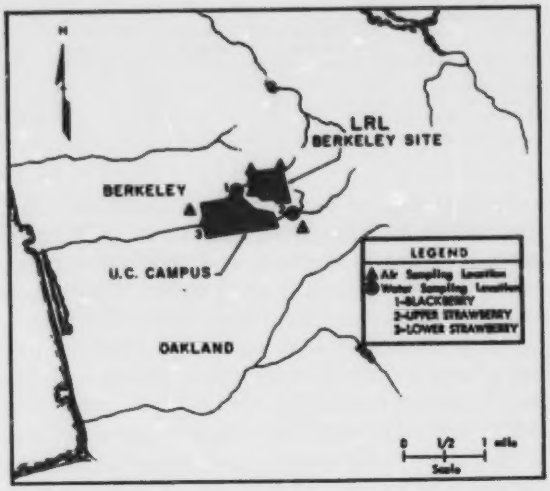

FIGURE 1.—ENVIRONMENTAL SAMPLING LOCATIONS AT THE BERKELEY SITE, LRL, 1962

Approximately 36 "stacks" (increased to 60 by the end of 1962), mostly laboratory hoods and glove box exhausts, are being sampled. These represent the greatest potential for releasing activity. One-inch-diameter filters are used at flow rate of one liter per minute. The filters are changed weekly and counted for beta by an end window G-M tube and for alpha by a zinc sulfide scintillation detector. Limits of detection for an individual stack sample were 0.12 pc/m³ alpha and 1.8 pc/m³ beta for the first half of 1962. The alpha limit was lowered to 0.10 pc/m³ for the last half of 1962. Local area and perimeter air samples are taken on outdoor areas on the Laboratory site and at the property line, respectively. The samples are taken on 4″ x 9″ HV–70 filter paper at 4 cfm. The filters are changed weekly and are counted for alpha by a large area gas flow proportional counter and for beta by two 30 mg/cm² G-M tubes. A 40% loss in the alpha count is assumed for self absorption. Limits of detection were 0.12 pc/m³ beta and 0.006 pc/m³ alpha for the first half of 1962. During the last half of 1962, the limits were 0.15 pc/m³ beta and 0.005 pc/m³ alpha. A reference sample on background sampling site is maintained at Building 903 in downtown Berkeley.

Rain or deposition samples are collected in 18-inch-diameter cylindrical vessels lined with poly-

TABLE 2.—TOTAL DEPOSITION—BERKELEY SITE, 1962

[Average concentrations in nc/m²]

Location	First half				Second half			
	No. of stations	No. of samples	Alpha	Beta	No. of stations	No. of samples	Alpha	Beta
Local area	3	64	0.15	444	5	61	<.18	195
Perimeter	4	87	0.19	355	3	36	<.27	154
Remote	2	11	0.03	300	1	5	<.22	78

etheylene bags at local area and perimeter sites. Deposition data are given in table 2. At two remote locations in Berkeley and Oakland, samples are collected in small rain gauges. The bag is changed weekly at all stations except Building 4, where it is changed after each rain. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid which is then evaporated. Final evaporation is in 2" diameter stainless steel planchets which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha in an internal flow proportional counter and for beta with a thin window low background Geiger flow counter. No correction is made for self-absorption in the sample. Detection limits vary depending on the size of the sample and length of time counted.

Water samples are taken from laboratory wastes, on-site streams and off-site streams. The laboratory waste is sampled at Buildings 70 and 71. At Building 70, a continuous sample of the chemistry building acid waste system is taken and analyzed weekly. This represents about ¼ of the total Laboratory discharge to the sewer. Samples of approximately two liters each are acidified, evaporated and counted in the same manner as rain samples. Detection limits vary but were no greater than 0.3 pc/liter beta for the first half of 1962. During the last half of 1962, the limits were no greater than 0.4 pc/liter alpha and 1 pc/liter beta.

Waste from laboratory areas in Building 71 is retained in 350-gallon holding tanks until analyzed. A one-quart sample is taken from each tank and is handled and counted in the same manner as samples taken at Building 70.

Surface water on the Laboratory site drains into two small streams which merge into one at the lower end of the University campus. One side stream (Upper Strawberry) and the final combined stream (Lower Strawberry) are sampled bi-weekly; the other side stream (Blackberry) is sampled weekly. Six nearby off-site creeks are also sampled. The four nearest ones are sampled bi-weekly, the other two more remote ones every four weeks. One-quart samples are taken in each case and handle in the same way as rain samples. The sampling stations are shown in figure 1. Results for all water samples are shown in table 3.

Livermore Site

The Livermore site of LRL is located three miles east of Livermore, California (figure 2). Technical facilities include a small cyclotron, a two-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

Environmental surveys are conducted for the purpose of detecting changes from normal or permissible concentrations that could be attributed to operations at the Laboratory. Air samples were collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples were collected to monitor radioactivity in an underground water supply which is the sole source of domestic water for the cities of Livermore and Pleasanton.

Air samples are collected continously at 11 sites within 5 miles of the LRL. The 4" x 9" HV-70 sampling papers are changed after seven days of

TABLE 3.—WATER MONITORING, BERKELEY SITE 1962

[Average concentrations in pc/liter]

Type of sample	Total number of samples	First half		Second half	
		Alpha	Beta	Alpha	Beta
Tap water	46	0.07	11.0	0.03	9.5
On-site streams	101	0.14	40.4	0.06	16.7
Off-site streams	124	0.10	22.6	0.06	6.8
Sewage (estimated)	—	0.09	13.1	0.09	11.0
Bldg. 70 acid waste	26	0.15	18.8	0.23	15.0
Bldg. 71 acid waste	7	1.22	58.8	1.29	44.1
Total activity discharged to sewage system (estimated)	—	1.9 μc	187 μc	5.0 μc	140 μc

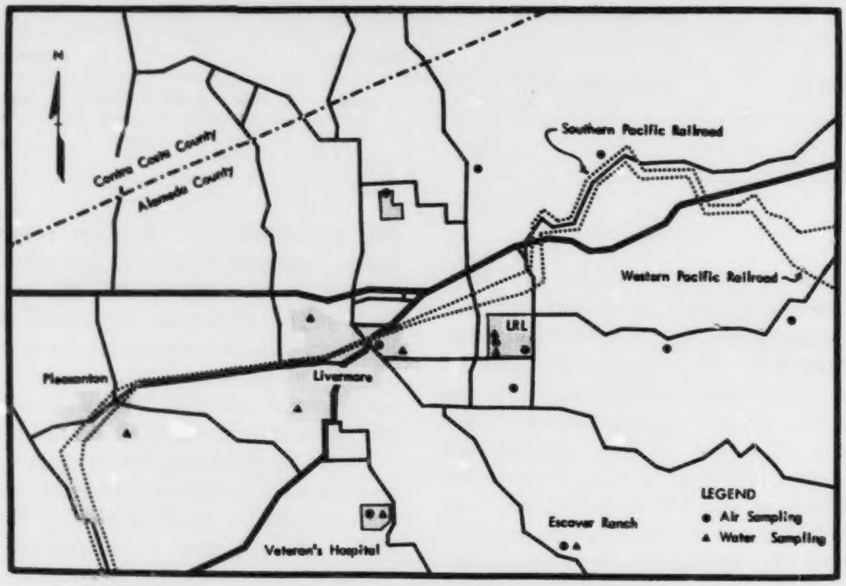

FIGURE 2.—ENVIRONMENTAL SAMPLING LOCATIONS AT THE LIVERMORE SITE, LRL, 1962

sampling at a rate of 4 cfm. A minimum decay period of 96 hours was observed before the papers were counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining was measured with a counter equipped with a zinc sulfide scintillation detector with a counting efficiency of about 30 percent. The beta activity was measured with a counter using an anthracene scintillation detector with a counting efficiency of about 13 percent. The standards of comparison used were 0.04 pc/m^3 for alpha and 19 pc/m^3 for beta as recommended in NBS handbook No. 69. The limit of sensitivity was 0.00073 pc/m^3 for alpha and 0.0059 pc/m^3 for beta. Results for air sampling at Livermore in 1962 are summarized in table 4.

Water samples were collected once a month at each station located on the underground water supply of the Livermore and Amador Valleys. The standards of comparison used were 10 pc/liter for alpha and 600 pc/liter beta as recommended in NBS handbook #69. The limit of sensitivity was 8.9 pc/liter for alpha and 41 pc/liter for beta. The gas proportional counter used in these measurements had a counting efficiency of 36 percent for alpha and 31 percent for beta emitters. Results of the water sample analyses are shown in table 5.

TABLE 4.—AIR MONITORING—LIVERMORE SITE, 1962

[Average concentrations in pc/m^3]

Distance from laboratory	No. of stations	First half			Second half		
		No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
0.5—1 mile	3	75	.0063	2.3	84	.0032	2.0
2—5 miles	8	195	.0052	2.4	223	.0039	2.0

TABLE 5.—RADIOACTIVITY IN UNDERGROUND WATER SUPPLY—LIVERMORE SITE, 1962

[Average concentrations in pc/liter]

Location	No. of stations	First half			Second half		
		No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Escover Ranch	1	5	<8.2	<68	6	<8.9	46
LRL	2	7	<8.2	<68	12	<8.9	<43
Livermore City	3	15	<8.2	<68	20	<8.9	<41
Pleasanton	1	5	<8.2	<68	6	<8.9	61
Veterans Hospital	1	5	<8.2	<68	6	<8.9	42

TABLE 6.—SAMPLING PROGRAM—SITE 300, 1962

Sample	No. of stations	First half			Second half		
		No. of samples	Alpha	Beta	No. of samples	Alpha	Beta
Air (pc/m³)	6	318	.0039	2.1	416	.0044	2.7
Water (pc/liter)	6	35	<8.2	<68	34	15	230

Site 300

Site 300 is part of the LRL operation at Livermore. The site is located in a very sparsely populated ranching area about 17 miles southeast of LRL at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal concentrations in the vicinity. Lack of power facilities necessitated installation of most of the air samplers within the boundaries of the site. All the water samples were taken from wells located on the site because they are the only readily accessible source of underground water in the area. All samples, air and water, are processed at LRL, Livermore.

Air sampling was on a continous basis at six stations, and the sampling paper was changed on an irregular schedule. The standards of comparison for alpha are 1 pc/m³ for the on-site stations and 0.1 pc/m³ for the off-site station located at Tracy, eight miles northeast of Site 300. The standards for beta are 1,000 pc/m³ on-site and 100 pc/m³ off-site. Average results for all air station samples combined are shown in table 6. During the first half of 1962, the concentrations of beta emitters averaged about twice the permissible levels for general population areas. The level is about the same as the observed Livermore environmental samples and is attributed to the remnants of fallout from the U.S.S.R. tests.

Water samples were taken at six on-site stations and one off-site station during the first half of 1962 and two off-site stations during the last half of 1962. The standards of comparison for alpha are 6,000 pc/liter for on-site locations and 600 pc/liter for off-site locations. For beta emitters, the standards are 30,000 pc/liter for on-site locations and 3,000 pc/liter for off-site locations. Average results for each half of 1962 are given in table 6.

Previous Coverage in *Radiological Health Data:*

Period	*Issue*
Fourth Quarter 1960	March 1962
First Half 1961	March 1962
Second Half 1961	October 1962

Tri-City Diet Study—Stable Strontium-Calcium Bone/Diet Observed Ratios, 1962[1]

Joseph Rivera[2]

One aspect of the program of investigation at the Health and Safety Laboratory on the passage of strontium-90 through food chains to man has been the determination of the concentrations of stable strontium present in the various components of the food chain and in man's skeleton.

An estimate of the degree of discrimination by the body between strontium and calcium can be made by comparing the ratio of these elements in the diet with the ratio found in bone (Observed Ratio). Estimates of stable strontium intake by residents of New York City, Chicago, and San Francisco were made in the quarterly report dated October 1, 1962 (HASL–131) (*1*, *2*). Additional data have been obtained and new estimates, calculated averaging all the data, are presented in table 1. At least two, and in some cases as many as four, samples from each food category were analyzed. There was considerable variability in the results obtained for most food categories but no seasonal effect was noted. The previously described geographic pattern of stable strontium intake is apparent in these estimates. The highest stable strontium intake is in San Franscisco, the lowest in New York City, with Chicago having values intermediate to these.

The data concerning food consumption of an average individual in the U.S. population, also shown in table 1, is from the U.S. Department of Agriculture, "Household Food Survey of 1955" (*6*). Since the calcium content of the various foods is relatively constant, the average intake of calcium, as revealed by the "Tri-City Diet Study" (*7*), is presented in table 1.

Data on the stable strontium content of human vertebrae have previously been reported in the quarterly report dated January 1, 1963 (HASL–132) (*3*, *4*). Additional data have been obtained and the averages of all the data are presented in table 2. Although the average concentration of stable strontium in adult and children's bones do not differ very much from those previously reported, the averages reported in table 2 have a greater statistical validity by virtue of the larger number of samples processed.

A summary of the data presented in tables 1 and 2 and the Observed Ratios $\left[\frac{\mathrm{Sr}}{\mathrm{Ca}}\ (\text{bone})/\frac{\mathrm{Sr}}{\mathrm{Ca}}\ (\text{diet})\right]$ found at the three cities is presented in table 3. The average calcium concentration found in the ashed vertebrae was 37 percent. This result has been used in calculating the Sr/Ca ratios.

Procedure

Most of the analyses of foods as well as bone were done by emission spectroscopy. A quality control program, intercomparing samples with results obtained by neutron activation analysis and by flame photometry on all types of matrices, showed generally good agreement between methods. The estimated precision of the analyses was ±5 percent. There was no evidence that bone samples were giving systematically lower results than food samples.

It has been assumed that vertebrae have the same strontium content as other parts of the skeleton. This assumption is supported by the research of Thurber, et al. (*5*) on the variability of strontium concentrations between bones in eleven cadavers.

Discussion

Adult Strontium-Calcium Discrimination: The bone-diet Observed Ratios for adults (>20 years old) are consistent with those previously reported (*4*) with each of the three cities having a ratio of 0.16. Because of the many uncertainties involved in estimating the intake of stable strontium and the variability noted in the stable strontium concentrations found in bone, the diet-bone Observed Ratio of 0.16 should be regarded only as a best estimate from the data available at present.

Child Strontium-Calcium Discrimination: The bone-diet Observed Ratios for children (1–20 years old) averaged 0.14 for the three cities with no significant differences observed between the cities. The difference between adult and child observed ratios are also statistically not significant.

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[1] Data abstracted from *Quarterly Summary Report, HASL–138*, pp, July 1963.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

TABLE 1.—ANNUAL AVERAGE PERSON DIETARY CONSUMPTION AND ANNUAL STABLE STRONTIUM INTAKE, 1962

Food category	Average U.S. consumption[1]		New York City		Chicago		San Francisco	
	Food (kg/yr)	Calcium (g/yr)	Concentration (mg Sr/kg food)	Intake (mg Sr/yr)	Concentration (mg Sr/kg food)	Intake (mg Sr/yr)	Concentration (mg Sr/kg food)	Intake (mg/yr)
Bakery products	37	37.0	2.46	91.0	2.54	94.0	1.96	72.5
Whole grain products	11	10.0	2.54	27.9	2.31	25.4	2.67	29.4
Eggs	16	9.1	1.19	19.0	1.29	20.6	1.21	19.4
Fresh vegetables	43	15.0	1.49	64.1	2.40	103.2	2.11	90.7
Root vegetables	17	6.1	2.59	44.0	4.95	84.2	5.33	90.6
Milk	221	234.3	0.32	70.7	0.26	57.5	0.76	168.0
Poultry	17	9.2	0.34	5.8	0.22	3.7	0.22	3.7
Fresh fish	8	10.8	4.89	39.1	3.31	26.5	2.24	17.9
Flour	43	8.6	0.51	21.9	0.69	29.7	0.58	24.9
Macaroni	3	0.7	0.52	1.6	0.64	1.9	0.81	2.4
Rice	3	1.1	0.21	0.6	0.18	0.5	0.32	1.0
Meat	73	10.9	0.17	12.4	0.18	13.1	0.16	11.7
Shellfish	1	0.8	13.9	13.9	5.64	5.6	7.73	7.7
Dried beans	3	2.9	3.27	9.8	3.94	11.8	3.98	11.9
Fresh fruit	68	13.6	1.28	87.0	1.54	104.7	1.43	97.2
Potatoes	45	5.8	0.70	31.5	1.23	55.4	0.99	44.6
Canned fruit	26	1.3	0.37	9.6	0.38	9.9	0.37	9.6
Fruit juices	19	1.7	0.42	8.0	0.70	13.3	0.52	9.9
Canned vegetables	20	4.2	1.51	30.2	1.74	34.8	0.77	15.4
Annual intake	674	383		588.1		695.8		728.5
Mg Sr/g Ca				1.53		1.82		1.90

[1] From the United States Department of Agriculture Household Consumption Survey of 1955 (*6*).

TABLE 2.—AVERAGE STABLE STRONTIUM IN HUMAN VERTEBRAE, 1962

Age at death (years)	New York City		Chicago		San Francisco	
	Number of samples	Strontium (ppm[a])	Number of samples	Strontium (ppm[a])	Number of samples	Strontium (ppm[a])
0- 1	3	69	1	96	3	122
1- 2	3	70			1	122
2- 3	3	80	2	77	2	130
3- 4	3	75	1	65	2	142
4- 5	3	66	1	116	2	137
5- 6	1	68			2	92
6- 7	2	63	1	61	2	106
7- 8	1	76	1	73	3	88
8- 9	1	130				
9-10	2	73	1	70		
10-12	1	78	1	133	2	111
12-14	3	76			1	77
14-16	3	111	1	68	2	183
16-18	3	76	1	71	2	150
18-20	3	79	1	73	2	158
20-40	4	86	2	113	4	87
40-60	3	105	2	98	4	124
>60	4	94	2	113	2	125
Averages:						
Infant 0-1 Yr.	3	69	1	96	3	122
Child 1-20 Yr.	32	78.8	11	80.4	23	123.5
Adult >20 Yr.	11	94.1	6	107.7	10	109.2

[a] Parts per million by weight in ash.

TABLE 3.—STABLE STRONTIUM IN BONE AND DIET, 1962

Location	Infant—0-1 year			Child—1-20 year			Adult— >20 year		
	mg Sr/g Ca		Bone/diet observed ratio	mg Sr/g Ca		Bone/diet observed ratio	mg Sr/g Ca		Bone/diet observed ratio
	Vertebrae[1]	Diet[2]		Vertebrae[1]	Diet[3]		Vertebrae[1]	Diet[3]	
New York City	0.19	0.61	0.31	0.21	1.53	0.14	0.25	1.53	0.16
Chicago	0.26	0.54	0.48	0.22	1.82	0.12	0.29	1.82	0.16
San Francisco	0.33	1.05	0.31	0.33	1.90	0.17	0.30	1.90	0.16
Average	—	—	0.37	—	—	0.14	—	—	0.16

[1] Average from table 2 assuming 37% calcium in ash. The error associated with the values is about 0.06 mg Sr/ Ca.
[2] From reference (*10*).
[3] From table 1.

Infant Strontium-Calcium Discrimination: It has been suggested by a number of studies (*3*, *4*) that the ability to discriminate between stable strontium and calcium in the passage of these elements from the diet to bone is less pronounced in the infancy than in later years. Estimates of the stable strontium and calcium intakes of infants during their first year of life from previous studies (*10*) were used in table 3.

The data do seem to confirm the hypothesis that there is less discrimination between strontium and calcium in infants than in adults.

The bone-diet Observed Ratios for infants (0–1 year old) averaged 0.37 for the three cities. It should be noted that the stable strontium content of infant bones from Chicago is based on the result of the analysis of a single bone sample, whereas for New York City and San Francisco, the average result from the analyses of three samples were used. It should further be noted that no account has been taken in these calculations of the Sr/Ca ratio of the bones of the infant at birth. The Sr/Ca ratio in infant bones is the result of dynamic exchanges between these initial concentrations of strontium and calcium derived from the mother and those subsequently derived from the infant's diet. It is obvious that much additional work will have to be done before a good estimate of the degree to which a child's body can discriminate between strontium and calcium is achieved.

Summary

The average bone/diet ratio of the stable strontium to calcium ratio was found to be about 0.15 for people in the age range <1 year old. If this number is correct, the body in fact prefers calcium about 7 times more than it prefers strontium.

For infants (0–1 year old) the tentative average bone/diet Observed Ratio is about 0.33 (weighted average). This represents a preference for calcium rather than strontium by a factor of about 3. The infants' ability to discriminate against strontium appears to be about one half that of adults. More work needs to be done on strontium-calcium discrimination in order to achieve greater statistical validity, particularly for infants.

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Previous Coverage in *Radiological Health Data:*

Period	*Issue*
1962	April 1963

Reported Nuclear Detonations

Through September 1963

The President indicated in his news conference, August 20, 1963, that there had been "36 atmospheric tests" and "97 . . . underground tests" conducted by the United States since the end of the voluntary moratorium on September 15, 1961.

The Atomic Energy Commission has announced that among the 36 tests described as atmospheric was one underwater burst. Also, the Commission has advised that the 97 tests included all nuclear events at the Nevada Test Site, except Sedan, the Plowshare Program cratering experiment of July 6, 1962. This means, in effect, that the President referred to 23 underground U. S. weapons related tests not previously announced. This number, therefore is included in the total of U. S. weapons related tests conducted since September 15, 1961, but no other data on the 23 tests are available for public use.

The Plowshare Program Project Gnome, conducted at Carlsbad, New Mexico (*1*), is not included in the above figures, but 2 joint United States-United Kingdom tests of British devices are included. Also, *Radiological Health Data* assigned the single test number 98 to the testing conducted at the Nevada Test Site on February 8, 1963. Information more recently received from the Atomic Energy Commission shows 2 tests conducted on that date. Thus, to bring the *Radiological Health Data* system of arbitrarily assigned test numbers into conformance with the Atomic Energy Commission records, the second test conducted on February 8, 1963, is assigned the number 111; the two U. S.-U. K. tests are assigned test numbers 112 and 113; and the 23 previously unannounced tests are assigned test numbers 114–136.

Two underground nuclear detonations at the Nevada Test Site were announced by the Atomic Energy Commission during September 1963. Both tests were conducted on September 13, one being in the low yield range, the other being in the intermediate range; the arbitrary reference numbers 137 and 138 are respectively assigned. (Low yield range means less than 20 kilotons; intermediate yield range is from 20 kilotons to one megaton.)

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more extensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air for July 1963 are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 5), which presents data on Canadian and U.S. gross beta radioactivity in air for July. To adjust the data from the two networks to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study.

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RADIATION SURVEILLANCE NETWORK
July 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) is made up of 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State Health Department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}-Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}-Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-

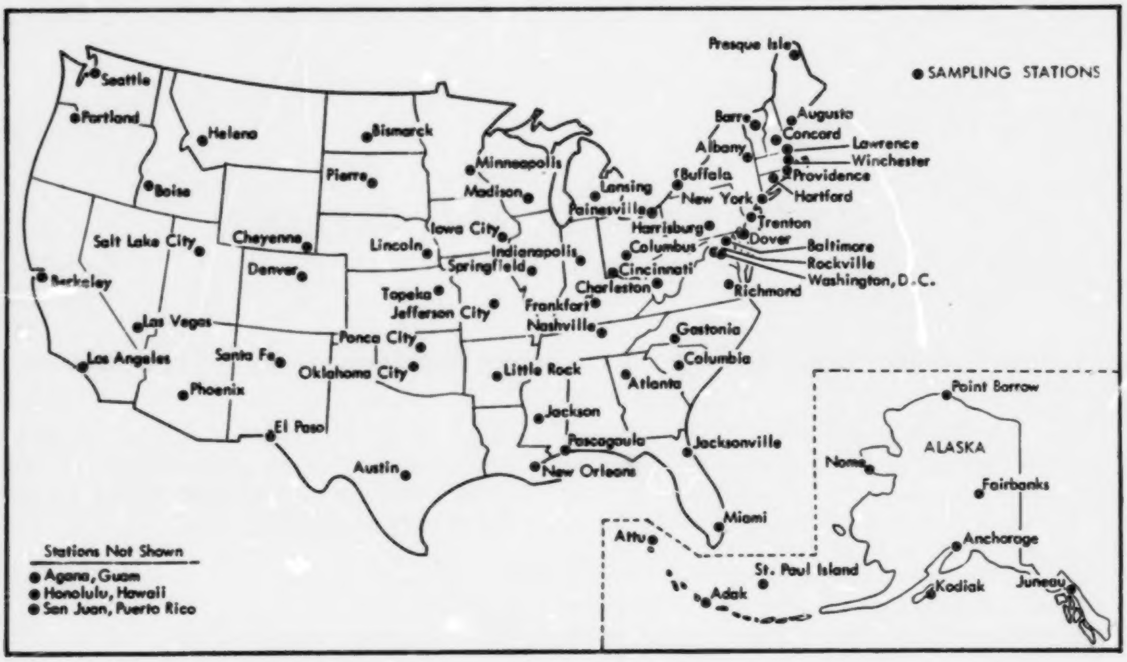
● SAMPLING STATIONS
Presque Isle
Seattle
Portland
Helena
Bismarck
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Minneapolis
Pierre
Boise
Madison
Lansing
Buffalo
Providence
Hartford
New York
Painesville
Iowa City
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Harrisburg
Trenton
Dover
Columbus
Baltimore
Rockville
Washington, D.C.
Cincinnati
Denver
Springfield
Berkeley
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Las Vegas
Nashville
Gastonia
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Atlanta
Phoenix
Jackson
El Paso
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, JULY 1963

Wigner formula: $AT^{1.2}$ = constant (*1*).[1] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during July 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1. These data (adjusted by the intercalibration factor 1.54),[2] together with corresponding Canadian data, are represented by isogram lines in figure 5, which show the distribution of fission product activity over most of North America.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. July 1963 averages of gross beta activity in precipitation, expressed as picocuries per liter and as nanocuries per square meter, are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *RHD*. The profiles of 7 stations, through July 1963, are shown in figure 2.

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(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review*, *73*:1318–30 (June 1948).
(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

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[1] In this expression, A is the activity and T is the time after fission product formation.

[2] See reference *1* on page 543.

TABLE 1.—FISSION PRODUCTS GROSS BETA ACTIVITY IN SURFACE AIR—RSN, JULY 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in RHD
Alaska:	Adak	28	5.2	<0.10	1.2	Nov. 63
	Anchorage	31	2.6	0.21	1.4	Jul. 63
	Attu	31	6.6	0.11	2.0	Dec. 62
	Fairbanks	29	6.2	0.12	2.5	Aug. 63
	Juneau	28	3.2	0.14	1.4	Sep. 63
	Kodiak	28	4.5	<0.10	1.2	Oct. 63
	Nome	0	—	—	—	Feb. 63
	Point Barrow	29	3.5	<0.10	1.1	Mar. 63
	St. Paul Island	19	4.6	<0.10	1.0	Apr. 63
Ariz.:	Phoenix	31	7.8	1.8	4.0	Sep. 63
Ark:	Little Rock	28	12	0.91	4.4	Sep. 63
Calif:	Berkeley	30	4.5	0.71	2.0	Oct. 63
	Los Angeles	22	6.6	2.1	4.5	Feb. 63
Colo:	Denver	25	7.6	1.4	4.0	Nov. 63
Conn:	Hartford	30	8.1	1.2	4.3	Oct. 63
Del:	Dover	20	14	2.4	7.2	Aug. 63
D.C:	Washington	31	13	3.3	7.0	Mar. 63
Fla:	Jacksonville	28	8.4	0.96	3.6	Oct. 63
	Miami	29	5.4	1.5	3.1	Feb. 63
Ga:	Atlanta	23	12	1.4	5.0	Jul. 63
Guam:	Agana	29	1.0	<0.10	0.39	Mar. 63
Hawaii:	Honolulu	31	5.1	0.31	2.3	Nov. 63
Idaho:	Boise	29	17	1.9	9.3	Dec. 62
Ill:	Springfield	30	8.1	1.7	5.0	Oct. 62
Ind:	Indianapolis	30	9.2	2.0	5.4	Jul. 63
Iowa:	Iowa City	31	7.7	1.8	4.6	Nov. 62
Kans:	Topeka	31	9.0	1.5	4.6	Jul. 63
Ky:	Frankfort	31	9.5	1.5	4.8	Mar. 63
La:	New Orleans	30	5.0	1.0	2.5	Nov. 62
Maine:	Augusta	30	9.6	0.53	4.9	Mar. 63
	Presque Isle	30	10	1.2	4.0	Nov. 63
Md:	Baltimore	21	9.6	2.7	5.9	Nov. 63
	Rockville	13	8.7	2.6	5.3	[b]
Mass:	Lawrence	28	12	1.0	5.8	Aug. 63
	Winchester	26	9.9	1.7	5.0	[b]
Mich:	Lansing	31	9.2	2.1	5.9	Apr. 63
Minn:	Minneapolis	30	7.6	1.5	4.7	Mar. 63
Miss:	Jackson	27	7.7	1.4	3.6	Mar. 63
	Pascagoula	8	3.0	0.54	1.6	Nov. 62
Mo:	Jefferson City	30	7.0	1.3	4.5	Nov. 63
Mont:	Helena	29	12	1.4	6.4	Nov. 63
Nebr:	Lincoln	15	13	2.1	5.2	Apr. 63
Nev:	Las Vegas	30	15	3.3	8.3	Jul. 63
N.H:	Concord	18	12	1.2	6.4	[b]
N.J:	Trenton	31	9.4	1.9	4.9	Oct. 62
N. Mex:	Santa Fe	29	5.2	1.1	2.6	Dec. 62
N.Y:	Albany	31	9.8	1.4	5.2	Jul. 63
	Buffalo	27	9.4	2.9	6.1	Nov. 63
	New York	20	8.6	1.3	4.8	Dec. 62
N.C:	Gastonia	30	13	1.9	5.7	Oct. 62
N. Dak:	Bismarck	29	9.9	2.4	5.6	Feb. 63
Ohio:	Cincinnati	22	7.0	1.8	4.6	Aug. 63
	Columbus	31	9.7	2.6	5.2	Feb. 63
	Painesville	30	10	3.0	7.0	Oct. 63
Okla:	Oklahoma City	29	5.1	1.1	2.7	Apr. 63
	Ponca City	30	5.7	0.70	2.0	Oct. 63
Ore:	Portland	30	8.2	1.3	3.6	Oct. 63
Pa:	Harrisburg	23	8.1	0.80	4.2	Dec. 62
P.R:	San Juan	31	4.4	0.65	3.0	Apr. 63
R.I:	Providence	29	10	1.9	5.2	Nov. 62
S.C:	Columbia	28	8.4	1.1	3.7	Dec. 62
S. Dak:	Pierre	30	7.7	1.9	4.1	Sep. 63
Tenn:	Nashville	29	14	1.3	6.0	Feb. 63
Tex:	Austin	29	4.2	1.1	2.3	Aug. 63
	El Paso	29	3.9	0.38	1.9	Feb. 63
Utah:	Salt Lake City	31	15	2.3	5.4	Aug. 63
Vt:	Barre	31	10	1.0	5.6	Sep. 63
Va:	Richmond	31	9.2	1.7	4.6	Sep. 63
Wash:	Seattle	30	3.7	0.82	1.8	Jul. 63
W. Va:	Charleston	28	8.0	1.8	4.5	[b]
Wisc:	Madison	29	11	2.5	6.8	Sep. 63
Wyo:	Cheyenne	31	9.3	1.4	4.4	Aug. 63
Network summary		1,966	15	<0.10	4.2	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION—RSN, JULY 1963

Station location		Average concentration (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	2,000	110
	Fairbanks	1,100	45
	Juneau	1,100	150
Ark:	Little Rock	510	53
Calif:	Berkeley	[b]—	[b]—
	Los Angeles	—	—
Colo:	Denver	—	—
Conn:	Hartford	1,900	140
D.C:	Washington	2,700	68
Fla:	Jacksonville	530	98
	Miami	820	15
Ga:	Atlanta	590	12
Idaho:	Boise	—	—
Ill:	Springfield	—	—
Ind:	Indianapolis	820	83
Iowa:	Iowa City	780	110
Kans:	Topeka	510	32
Ky:	Frankfort	1,000	41
La:	New Orleans	820	140
Maine:	Augusta	1,800	130
	Presque Isle	1,200	88
Md:	Baltimore	2,500	99
Mass:	Lawrence	2,500	180
	Winchester	2,100	94
Mich:	Lansing	700	42
Minn:	Minneapolis	1,200	53
Miss:	Jackson	1,400	150
Mo:	Jefferson City	820	58
Mont:	Helena	5,000	98
Nebr:	Lincoln	1,400	69
Nev:	Las Vegas	—	—
N.J:	Trenton	1,300	27
N. Mex:	Santa Fe	1,200	39
N.Y:	Albany	1,000	38
	Buffalo	—	—
N.C:	Gastonia	860	40
N. Dak:	Bismarck	2,000	110
Ohio:	Columbus	1,500	120
	Painesville	1,200	97
Okla:	Oklahoma City	540	35
	Ponca City	420	71
Ore:	Portland	740	22
Pa:	Harrisburg	970	33
P.R:	San Juan	480	44
R.I:	Providence	2,500	230
S.C:	Columbia	1,200	130
S. Dak:	Pierre	1,100	110
Tenn:	Nashville	1,200	110
Tex:	Austin	780	0.98
	El Paso	680	13
Utah:	Salt Lake City	—	—
Vt:	Barre	1,400	110
Va:	Richmond	1,400	14
Wash:	Seattle	2,000	40
W. Va:	Charleston	850	76
Wisc:	Madison	940	75
Wyo:	Cheyenne	1,900	16

[a] Depth of precipitation (mm) $= \frac{\text{deposition (nc/m}^2\text{) x 1000}}{\text{concentration (pc/liter)}}$

[b] Dash indicates no evaporated sample received.

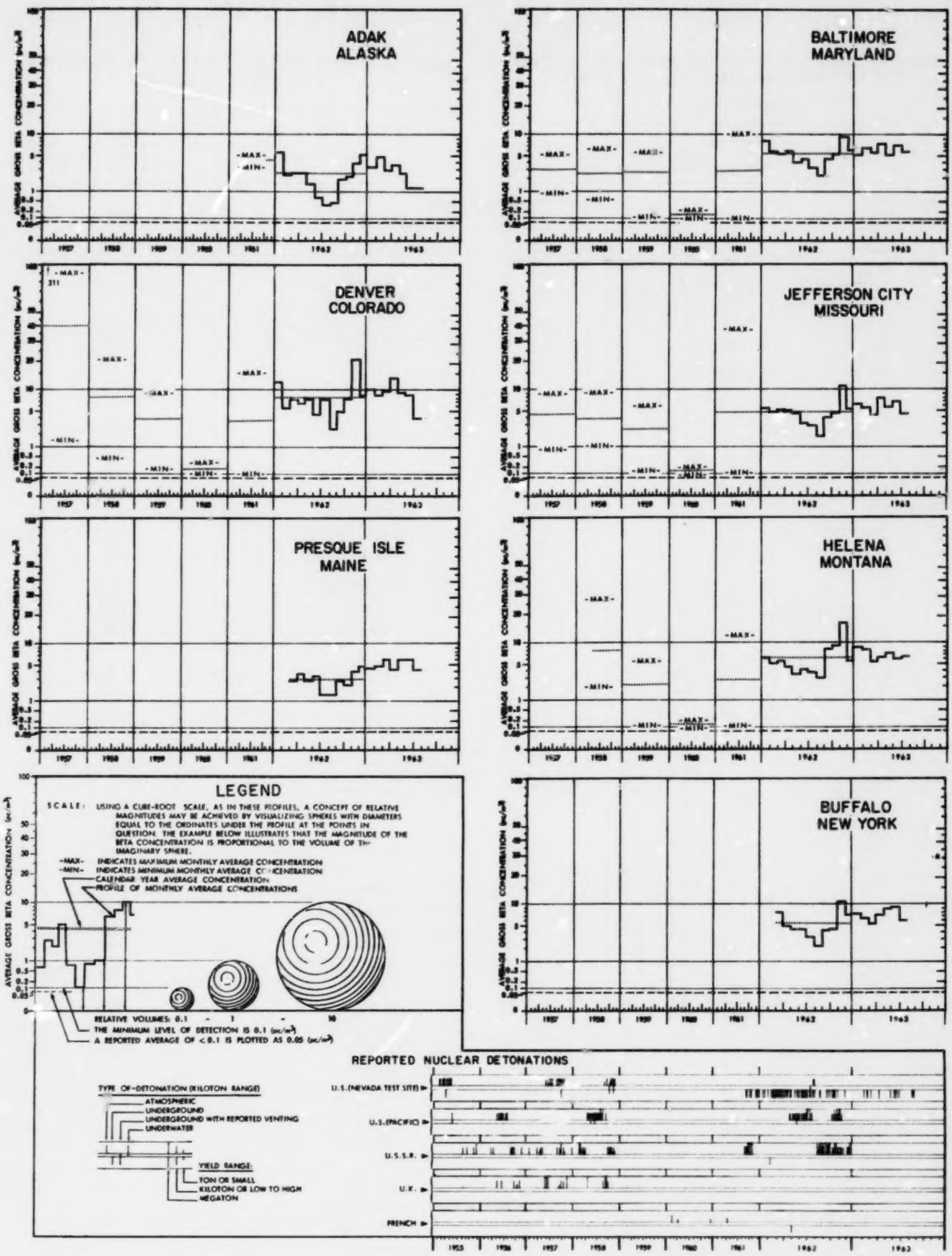

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1957—JULY 1963

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CANADIAN AIR MONITORING PROGRAM
July 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 3) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission pro-

TABLE 3.—FISSION PRODUCTS GROSS BETA ACTIVITY IN AIR—RFSP, JULY 1963

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	31	20.8	3.3	9.7
Coral Harbour	30	11.8	0.4	4.4
Edmonton	31	12.0	1.2	7.2
Ft. Churchill	30	10.0	0.1	3.6
Ft. William	30	16.2	0.3	7.3
Fredericton	31	13.3	1.8	5.4
Goose Bay	31	16.2	0.1	5.6
Halifax	31	15.0	1.6	6.0
Inuvik	31	18.7	1.1	5.1
Montreal	30	15.4	1.2	7.6
Moosonee	30	17.0	1.1	6.9
Ottawa	31	21.3	1.3	7.9
Quebec	31	17.1	0.6	6.7
Regina	31	26.7	3.3	9.4
Resolute	30	4.6	0.2	1.9
St. John's	28	12.5	0.6	4.1
Saskatoon	31	28.0	1.0	11.7
Sault Ste. Marie	31	14.9	0.4	8.8
Toronto	31	12.5	0.7	7.7
Vancouver	31	9.2	1.7	4.0
Whitehorse	31	11.0	0.7	4.5
Windsor	31	16.8	4.2	9.6
Winnipeg	31	20.8	0.4	8.7
Yellowknife	31	18.3	0.6	5.0
Network summary	735	15.8	1.2	6.6

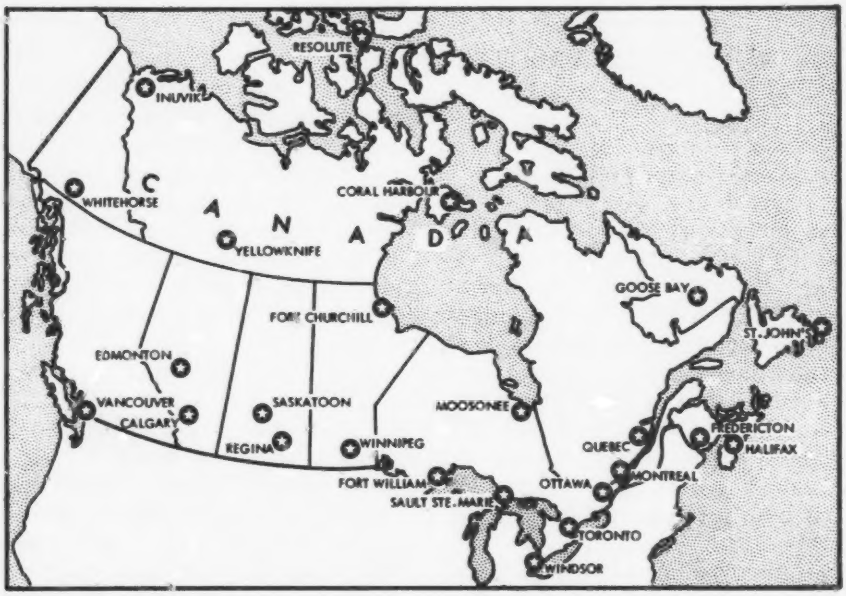
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, JULY 1963

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION—RFSP, JULY 1963

Station	Total beta activity	
	nc/m²	pc/liter
Calgary	411.8	4,559
Coral Harbour	116.1	4,866
Edmonton	259.2	3,991
Ft. Churchill	190.1	2,805
Ft. William	119.7	4,249
Fredericton	257.0	2,164
Goose Bay	216.5	1,050
Halifax	130.9	2,344
Inuvik	154.4	2,504
Montreal	—[a]	—[a]
Moosonee	184.7	3,622
Ottawa	212.6	2,696
Quebec	157.5	1,219
Regina	282.5	2,129
Resolute	[b]	[b]
St. John's	96.9	1,405
Saskatoon	331.8	4,494
Sault Ste. Marie	173.5	3,106
Toronto	144.9	2,562
Vancouver	126.4	1,961
Whitehorse	77.3	2,308
Windsor	125.7	2,949
Winnipeg	—	—
Yellowknife	177.8	3,320
Average	188.0	2,869

[a] Dash indicates no analysis.
[b] Blank space indicates no sample.

ducts. The results are extrapolated to the end of the sampling period. Canadian air data for July 1963 are given in table 3 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container the polythene liner is removed, packed with the sample, and sent to the laboratory. Beta activities in precipitation for stations in Canada are presented in table 4.

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(*4*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monotoring Program, RPD-11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

MEXICAN AIR MONITORING PROGRAM
April and May 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the "Comision Nacional de Energía Nuclear" (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation.

Prior to the establishment of the network, two pilot sampling stations were set up (in Mexico City and San Luis Potosí), to aid in the selection of equipment and sampling sites. Since April 1962 the network has been gradually expanded to 15 stations (see figure 4).

Ten of the 15 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the RPP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via airmail to the "Laboratorio de Desechos Radiactivos," CNEN, in Mexico City for assay of gross beta activity. A

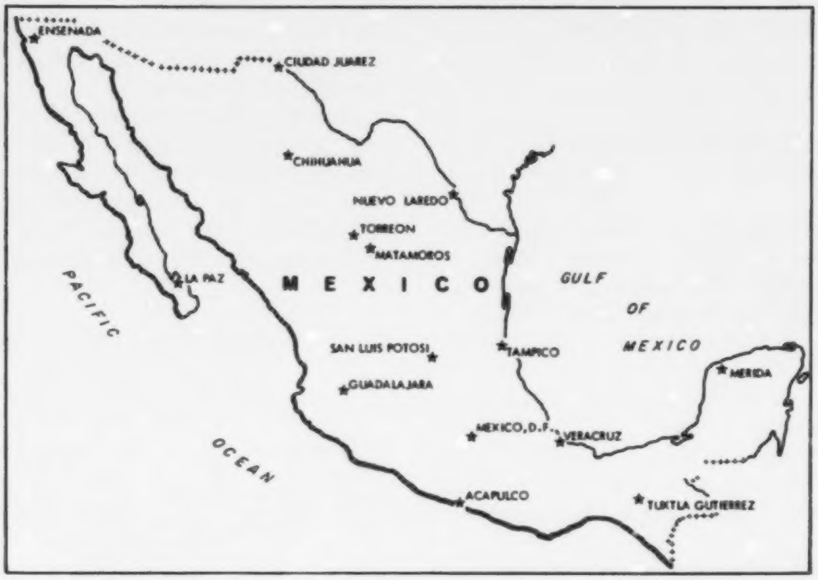
ENSENADA
CIUDAD JUAREZ
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
M E X I C O
PACIFIC
GULF
OF
MEXICO
SAN LUIS POTOSI
TAMPICO
MERIDA
GUADALAJARA
MEXICO, D.F.
VERACRUZ
OCEAN
ACAPULCO
TUXTLA GUTIERREZ

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum, and average concentrations of fission product beta activity in surface air during April and May 1963 are presented in tables 5 and 6.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES—MEXICO, APRIL 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	11	12.8	3.1	7.5
Ciudad Juárez	16	23.5	5.1	11.2
Ensenada	11	23.9	3.9	8.1
Guadalajara	6	17.7	4.6	8.3
La Paz	13	16.8	4.1	8.8
Mérida	15	18.0	4.8	8.0
México, D.F.	14	20.8	2.3	7.4
Nuevo Laredo	4	10.7	5.9	8.6
San Luis Potosí	7	14.4	6.6	9.7
Torreón	14	19.8	2.9	5.7
Tuxtla Gutierrez	15	15.1	3.2	6.3
Veracruz	25	17.1	5.8	8.8
Tampico	6	9.6	4.5	6.3
Matamoros	10	10.1	5.7	7.3
Network summary	167	23.5	2.3	8.1

[a] Because the counting system was out of order the samples were counted an average of 40 days after collection. Data are not extrapolated to time of collection.

TABLE 6.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES—MEXICO, MAY 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	4	9.4	2.9	5.7
Ciudad Juárez	15	16.4	2.8	6.9
Chihuahua	4	22.7	5.5	10.5
Ensenada	10	6.8	1.6	4.6
Guadalajara	12	15.5	3.2	6.0
La Paz	8	13.1	7.2	9.5
Matamoros	22	9.0	2.9	5.8
Mérida	17	9.1	2.1	5.3
México	14	7.8	1.0	4.4
Nuevo Laredo	6	8.8	4.4	7.3
San Luis Potosí	13	9.2	0.9	5.4
Tampico	13	7.8	3.2	5.8
Torreón	17	8.7	3.8	5.8
Tuxtla Gutierrez	17	15.2	3.3	7.4
Veracruz	16	11.0	3.5	6.6
Network summary	188	22.7	0.9	6.9

Recent coverage in *Radiological Health Data:*

Period	*Issue*
January 1963	*May 1963*
February 1963	*June 1963*
March 1963	*July 1963*

PAN AMERICAN AIR SAMPLING PROGRAM
July 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is being monitored at three locations in South America under the auspices of a collaborative radiological health program between the Pan American Health Organization (PAHO) and the Public Health Service (PHS).

The three air sampling stations presently included in the program are located in Santiago, Chile; Lima, Peru; and Caracas, Venezuela. The Caracas station was activated in November 1962 and the other two stations entered in December of the same year.

The air sampling stations are manned by local personnel, and the sampling equipment and laboratory analyses are provided by the Public Health Service. Equipment and counting procedures are identical with those employed for the Radiation Surveillance Network.

Fission product gross beta activity data for July 1963 are presented in table 7. The higher monthly average values noted for Caracas, in comparison with values for corresponding months for Lima and Santiago, are consistent with the Northern Hemisphere location of the Caracas station.

TABLE 7.—GROSS BETA ACTIVITY IN AIR—PAASP, JULY 1963

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average[1]
Caracas, Venezuela	22	2.43	0.26	0.93
Lima, Peru[2]	0			
Santiago, Chile	5	0.21	<0.10	<0.15

[1] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[2] The Lima, Peru, station was not in operation during the month of July because of mechanical difficulties.

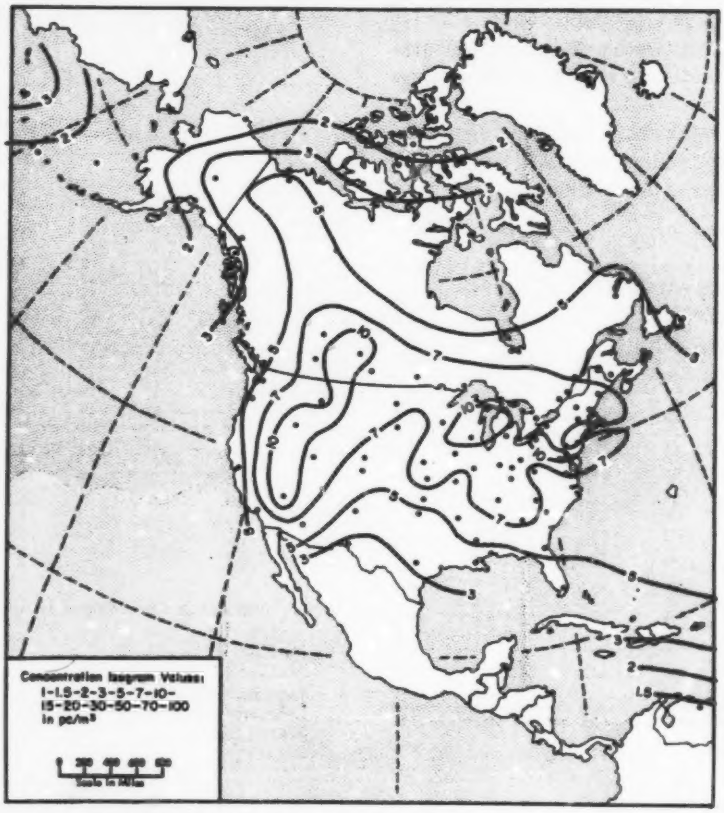

FIGURE 5.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAMS FOR INTER-CALIBRATED NETWORKS, JULY 1963

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SECTION II.—MILK AND FOOD

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
July 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. Table 1 shows the growth of the network since its initiation in March 1960. More milk sampling points continued to be added until July 1962, when the total number of stations reached 62.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, or Northeastern Radiological Health Laboratories for analysis. Approximately 3–6 days after sample collection, any results from the gamma analyses which indicate concentrations of iodine–131 greater than 100 pc/liter are made available to the States for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could

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TABLE 1.—DATE OF INCLUSION OF STATIONS IN PASTEURIZED MILK NETWORK

Sampling locations		Date of inclusion in PMN	Sampling locations		Date of inclusion in PMN	Sampling locations		Date of inclusion in PMN
Ala:	Montgomery	October 1961	Md:	Baltimore	August 1960	Okla:	Oklahoma City	July 1960
Alaska:	Palmer	March 1960	Mass:	Boston	June 1960	Ore:	Portland	April 1960
Ariz:	Phoenix	July 1960	Mich:	Detroit	July 1960	Pa:	Philadelphia	June 1960
Ark:	Little Rock	August 1960		Grand Rapids	July 1960		Pittsburgh	April 1960
Calif:	Sacramento	August 1960	Minn:	Minneapolis	August 1960	P. R.:	San Juan	July 1960
	San Francisco	June 1960	Miss:	Jackson	August 1960	R. I.:	Providence	June 1960
Colo:	Denver	March 1960	Mo:	Kansas City	April 1960	S. C.:	Charleston	August 1960
Conn:	Hartford	April 1960		St. Louis	August 1960	S. Dak:	Rapid City	January 1962
Del:	Wilmington	June 1960	Mont:	Helena	June 1960	Tenn:	Chattanooga	August 1960
D. C.:	Washington	July 1960	Nebr:	Omaha	August 1960		Memphis	September 1960
Fla:	Tampa	August 1960	Nev:	Las Vegas[1]	July 1962	Texas:	Austin	June 1960
Ga:	Atlanta	August 1960	N. H.:	Manchester	April 1960		Dallas	June 1960
Hawaii:	Honolulu	April 1960	N. J.:	Trenton	June 1960	Utah:	Salt Lake City	March 1960
Idaho:	Idaho Falls	March 1960	N. Mex:	Albuquerque	March 1960	Vt:	Burlington	April 1960
Ill:	Chicago	July 1960	N. Y.:	Buffalo	June 1960	Va:	Norfolk	July 1960
Ind:	Indianapolis	July 1960		New York	June 1960	Wash:	Seattle	April 1960
Iowa:	Des Moines	June 1960		Syracuse	April 1960		Spokane	May 1960
Kans:	Wichita	April 1960	N. C.:	Charlotte	June 1960	W. Va:	Charleston	April 1960
Ky:	Louisville	April 1960	N. Dak:	Minot	September 1961	Wis:	Milwaukee	July 1960
La:	New Orleans	July 1960	Ohio:	Cincinnati	August 1960	Wyo:	Laramie	April 1960
Maine:	Portland	June 1960		Cleveland	July 1960			

Date	Mar '60	Apr '60	May '60	Jun '60	Jul '60	Aug '60	Sept '60	Sept '61	Oct '61	Jan '62	Jul '62
Number of Stations Reporting	5	18	19	33	45	57	58	59	60	61	62

[1] Some Las Vegas milk data were published in *Radiological Health Data* prior to the station's inclusion into the Pasteurized Milk Network.

be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as the measured concentration at which the statistical two-standard-deviation analytical error is 100 percent (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10: Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Summaries of the analyses for July 1963, (June 30–July 27, 1963) are presented in table 2. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.3 to 1.8 grams/liter. In July, for example, 9, 20, 11, 20, and 2 stations recorded respective monthly average potassium concentrations of 1.3, 1.4, 1.5, 1.6, and 1.7 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. In order to show the distribution of the network's station versus radionuclide concentrations in milk, table 3 has been

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, JULY 1963

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Last Profile in RHD
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Month (1963)
Ala:	Montgomery	1.21	1.18	100	65	23	21	<10	<10	80	100	10	<10	Oct.
Alaska:	Palmer	1.17	1.17	35	45	15	19	<10	<10	55	110	<10	<10	Nov.
Ariz:	Phoenix	1.16	1.14	20	10	5	3	<10	<10	15	15	<10	<10	Sep.
Ark:	Little Rock	1.19	1.19	200	130	51	42	<10	<10	195	170	20	<10	Nov.
Calif:	Sacramento	1.21	1.19	115	20	19	11	<10	<10	90	50	<10	<10	Aug.
	San Francisco	1.22	1.18	175	30	27	12	<10	<10	110	75	<10	<10	Oct.
Colo:	Denver	1.23	1.19	35	60	14	26	<10	<10	70	135	<10	<10	Aug.
Conn:	Hartford	1.09	1.18	30	50	22	38	<10	<10	120	245	<10	<10	Aug.
Del:	Wilmington	1.07	1.12	65	40	28	34	<10	<10	130	165	<10	<10	Sep.
D. C:	Washington	1.16	1.07	90	70	24	22	<10	<10	120	140	<10	<10	Sep.
Fla:	Tampa	1.18	1.21	40	30	13	14	<10	<10	200	255	10	<10	Sep.
Ga:	Atlanta	1.21	1.22	145	110	33	36	<10	<10	155	260	10	<10	Oct.
Hawaii:	Honolulu	1.15	1.20	60	20	10	14	<10	<10	65	85	<10	<10	Nov.
Idaho:	Idaho Falls	1.20	1.18	80	125	22	49	<10	<10	110	225	<10	<10	Sep.
Ill:	Chicago	1.06	1.26	30	50	21	22	<10	<10	95	155	<10	<10	Oct.
Ind:	Indianapolis	1.10	1.18	55	50	29	28	<10	<10	100	120	<10	<10	Aug.
Iowa:	Des Moines	1.19	1.16	145	80	31	31	<10	<10	95	90	<10	<10	Sep.
Kans:	Wichita	1.19	1.17	90	65	21	32	<10	<10	85	95	<10	<10	Nov.
Ky:	Louisville	1.18	1.14	180	150	37	42	<10	<10	125	160	10	<10	Sep.
La:	New Orleans	1.23	1.22	175	125	45	41	10	<10	170	175	20	<10	Nov.
Maine:	Portland	1.07	1.22	30	65	25	42	<10	<10	120	310	<10	<10	Sep.
Md:	Baltimore	1.15	1.16	105	95	24	28	<10	<10	140	185	10	<10	Sep.
Mass:	Boston	1.10	1.21	35	80	28	54	<10	<10	150	285	<10	<10	Oct.
Mich:	Detroit	1.08	1.16	25	30	20	28	<10	<10	85	125	<10	<10	Aug.
	Grand Rapids	1.11	1.19	25	40	19	23	<10	<10	90	135	<10	<10	Sep.
Minn:	Minneapolis	1.20	1.17	80	110	28	38	<10	<10	130	200	<10	<10	Oct.
Miss:	Jackson	1.25	1.24	180	125	38	36	<10	<10	120	140	20	<10	Aug.
Mo:	Kansas City	1.21	1.15	155	80	32	28	<10	<10	100	85	<10	<10	Aug.
	St. Louis	1.19	1.18	110	80	27	30	<10	<10	95	100	<10	<10	Nov.
Mont:	Helena	1.19	1.17	70	135	21	44	<10	<10	105	295	<10	<10	Nov.
Nebr:	Omaha	1.21	1.20	100	85	27	33	<10	<10	90	125	<10	<10	Sep.
Nev:	Las Vegas	1.15	1.16	25	30	7	16	<10	<10	50	110	<10	<10	Oct.
N. H:	Manchester	1.12	1.26	40	60	28	50	<10	<10	170	380	<10	<10	Sep.
N. J:	Trenton	1.09	1.20	40	40	26	32	<10	<10	110	200	<10	<10	Aug.
N. Mex:	Albuquerque	1.16	1.16	40	35	10	12	<10	<10	35	50	<10	<10	Nov.
N. Y:	Buffalo	1.06	1.16	30	50	22	28	<10	<10	105	160	<10	<10	Aug.
	New York	1.09	1.15	40	80	24	44	<10	<10	110	195	<10	<10	Oct.
	Syracuse	1.08	1.22	35	60	24	34	<10	<10	105	165	<10	<10	Nov.
N. C:	Charlotte	1.25	1.20	135	125	34	35	<10	<10	130	185	10	<10	Nov.
N. Dak:	Minot	1.13	1.13	180	195	48	67	<10	<10	115	195	<10	<10	Sep.
Ohio:	Cincinnati	1.09	1.20	75	65	31	30	<10	<10	90	115	<10	<10	Aug.
	Cleveland	1.13	1.14	[a] 40	60	24	28	<10	<10	100	125	<10	<10	Nov.
Okla:	Oklahoma City	1.17	1.13	130	85	28	24	<10	<10	120	115	10	<10	Oct.
Ore:	Portland	1.24	1.23	165	80	38	34	<10	<10	160	195	<10	<10	Aug.
Pa:	Philadelphia	1.08	1.18	55	60	29	30	<10	<10	130	165	<10	<10	Nov.
	Pittsburgh	1.10	1.20	55	90	27	33	<10	<10	125	195	<10	<10	Nov.
P. R:	San Juan	1.16	1.12	105	50	18	14	<10	<10	125	120	10	<10	Nov.
R. I:	Providence	1.08	1.19	45	60	27	45	<10	<10	125	255	<10	<10	Sep.
S. C:	Charleston	1.21	1.19	100	80	29	26	<10	<10	120	165	10	<10	Aug.
S. Dak:	Rapid City	0.92	0.93	105	160	34	56	<10	<10	125	210	<10	<10	Oct.
Tenn:	Chattanooga	1.22	1.23	195	170	40	48	<10	<10	160	260	10	<10	Oct.
	Memphis	1.22	1.18	160	120	38	34	<10	<10	110	135	10	<10	Sep.
Tex:	Austin	1.14	1.14	50	40	10	9	<10	<10	50	60	<10	<10	Oct.
	Dallas	1.16	1.19	120	60	25	20	<10	<10	100	80	10	<10	Aug.
Utah:	Salt Lake City	1.22	1.19	45	90	20	39	<10	<10	110	270	<10	<10	Nov.
Vt:	Burlington	1.09	1.16	30	70	24	43	<10	<10	110	235	<10	<10	Aug.
Va:	Norfolk	1.17	1.16	95	70	25	22	<10	<10	120	140	10	<10	Aug.
Wash:	Seattle	1.19	1.18	125	85	26	38	<10	<10	150	215	<10	<10	Oct.
	Spokane	1.26	1.22	105	95	27	38	<10	<10	125	185	<10	<10	Aug.
W. Va:	Charleston	1.17	1.14	145	125	37	36	<10	<10	115	145	10	<10	Oct.
Wis:	Milwaukee	1.10	1.26	30	40	20	25	<10	<10	90	135	<10	<10	Sep.
Wyo:	Laramie	1.20	1.16	70	80	24	38	<10	<10	120	140	<10	<10	Sep.
Network average		1.16	1.18	87	77	25.9	31.4	<10	<10	112	163	<10	<10	Nov.

[a] *Correction for October 1963 issue:* The second quarter strontium-89 average given in table 1 on page 500 was incorrectly reported as 49 pc/liter and should have been 40 pc/liter.

prepared using the monthly average data shown in table 2.

Figure 3 shows strontium–89, strontium–90, iodine–131, and cesium–137 maximum, average, and minimum monthly station values.

Iodine–131 has not appeared appreciably in milk during January through July 1963. The greatest monthly average concentration observed at any station during this period was 40 pc/liter. During May through July 1963 no concentrations greater than 10 pc/liter have been reported.

The network average strontium–89 concentrations in milk increased from 34 pc/liter in January to 106 pc/liter in June and then fell to 77 pc/liter

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, JULY 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5-20	3	<1-9	2	<10	62	<5-45	1	<10	62
25-45	11	10-19	8			50-95	9		
50-70	19	20-29	16			100-145	20		
75-95	15	30-39	22			150-195	16		
100-120	3	40-49	10			200-245	7		
125-145	7	50-59	3			250-295	7		
150-170	3	60-69	1			300-345	1		
175-195	1					350-395	1		

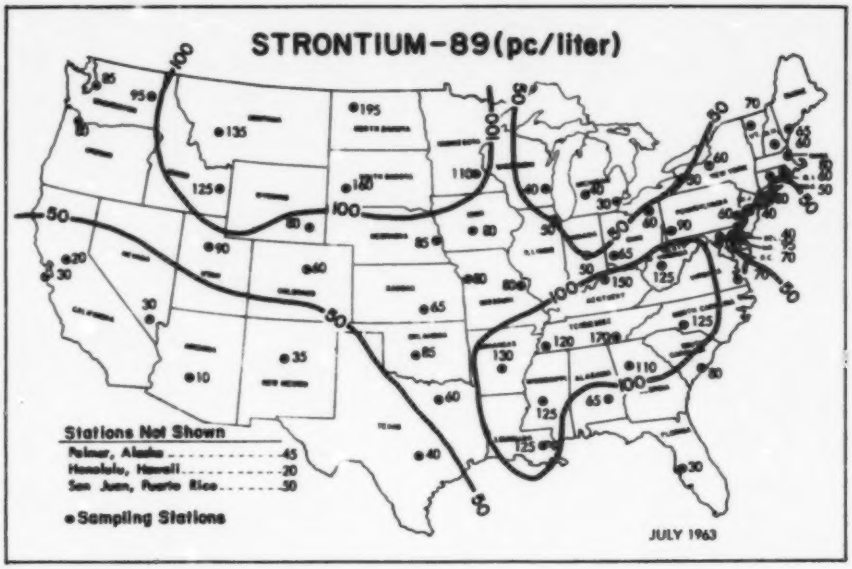
STRONTIUM-89(pc/liter)
100
50
80
Stations Not Shown
Palmer, Alaska 45
Honolulu, Hawaii 20
San Juan, Puerto Rico 50
● Sampling Stations
JULY 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, JULY 1963

in July. Nationally, levels in the Mississippi valley have been high while levels in the Southwest have been low. In January and February, only the stations in the lower Mississippi valley reported monthly average strontium-89 concentrations as high as 150 to 270 pc/liter. In this same area in March levels ranged from 200 to 365 pc/liter. In April and May monthly average concentrations in the area remained at the 200 pc/liter level. Additionally, during these two months, levels of between 200 and 250 were observed along the west coast from Washington to California. During June all stations except three had average concentrations below 200 pc/liter. During July, 45 of the 62 stations reported strontium-89 concentrations of 25 to 95 pc/liter.

The network average strontium-90 concentration in milk increased from 15 pc/liter in January to the low thirties in June and July. During January and February all stations reported monthly average strontium-90 concentrations of between 10 and 36 pc/liter, except those in the Southwest, which reported less than 10 pc/liter. The lower Mississippi valley area had concentrations in the high thirties and low forties in March. By April this area was experiencing concentrations in the low fifties. During the months of May through July the lower Mississippi Valley area and the mid-South were reporting values in the forties. Average concentrations of 40-62 pc/liter began to appear in the northern part of the country from Idaho to Minnesota during these same three

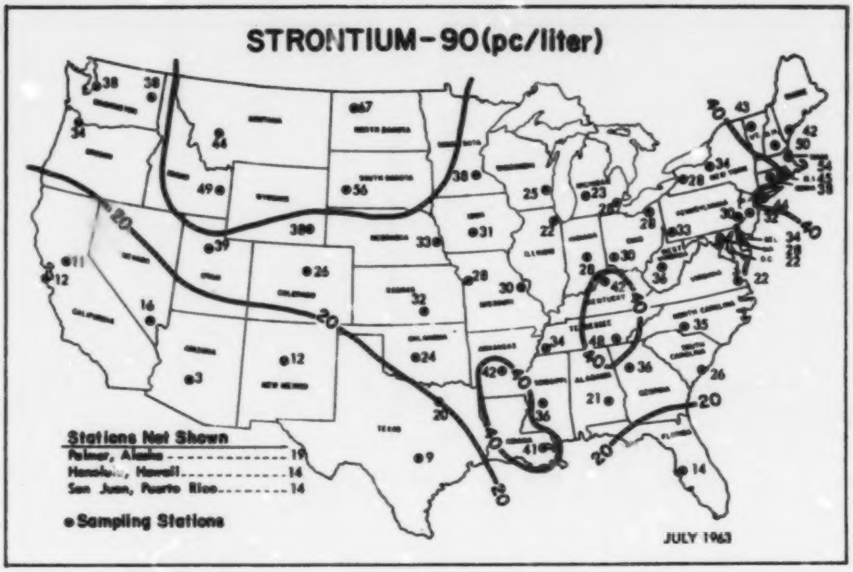
STRONTIUM-90 (pc/liter)
20
20
20
40
40
40
20
Stations Not Shown
Palmer, Alaska 19
Honolulu, Hawaii 14
San Juan, Puerto Rico 14
● Sampling Stations
JULY 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JULY 1963

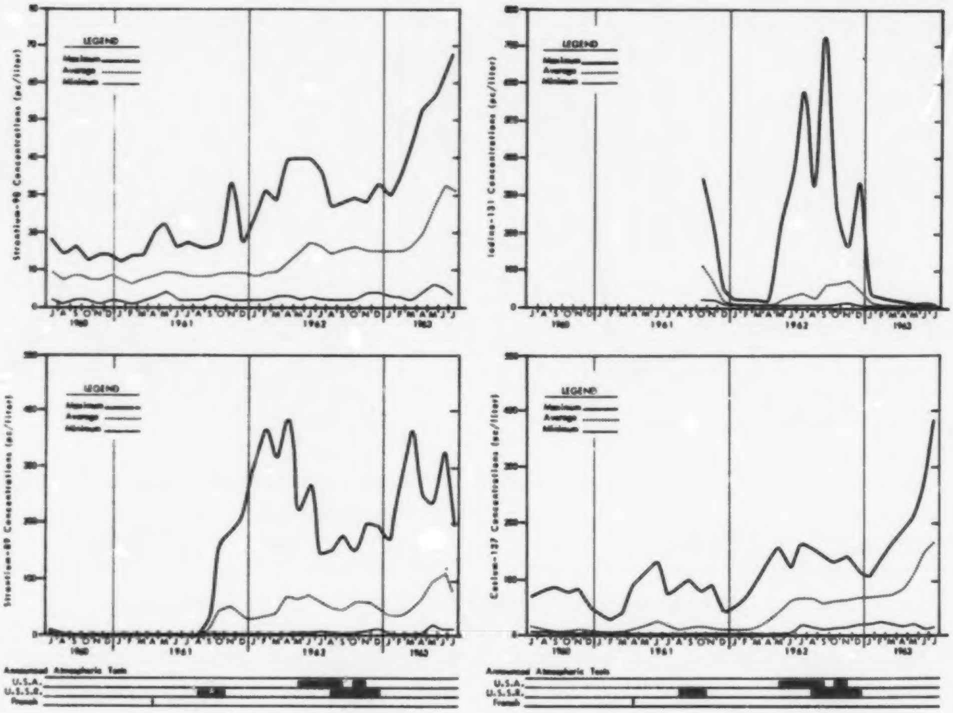

FIGURE 3.—PASTEURIZED MILK NETWORK MAXIMUM, AVERAGE, AND MINIMUM MONTHLY AVERAGES OF RADIONUCLIDE CONCENTRATIONS IN MILK

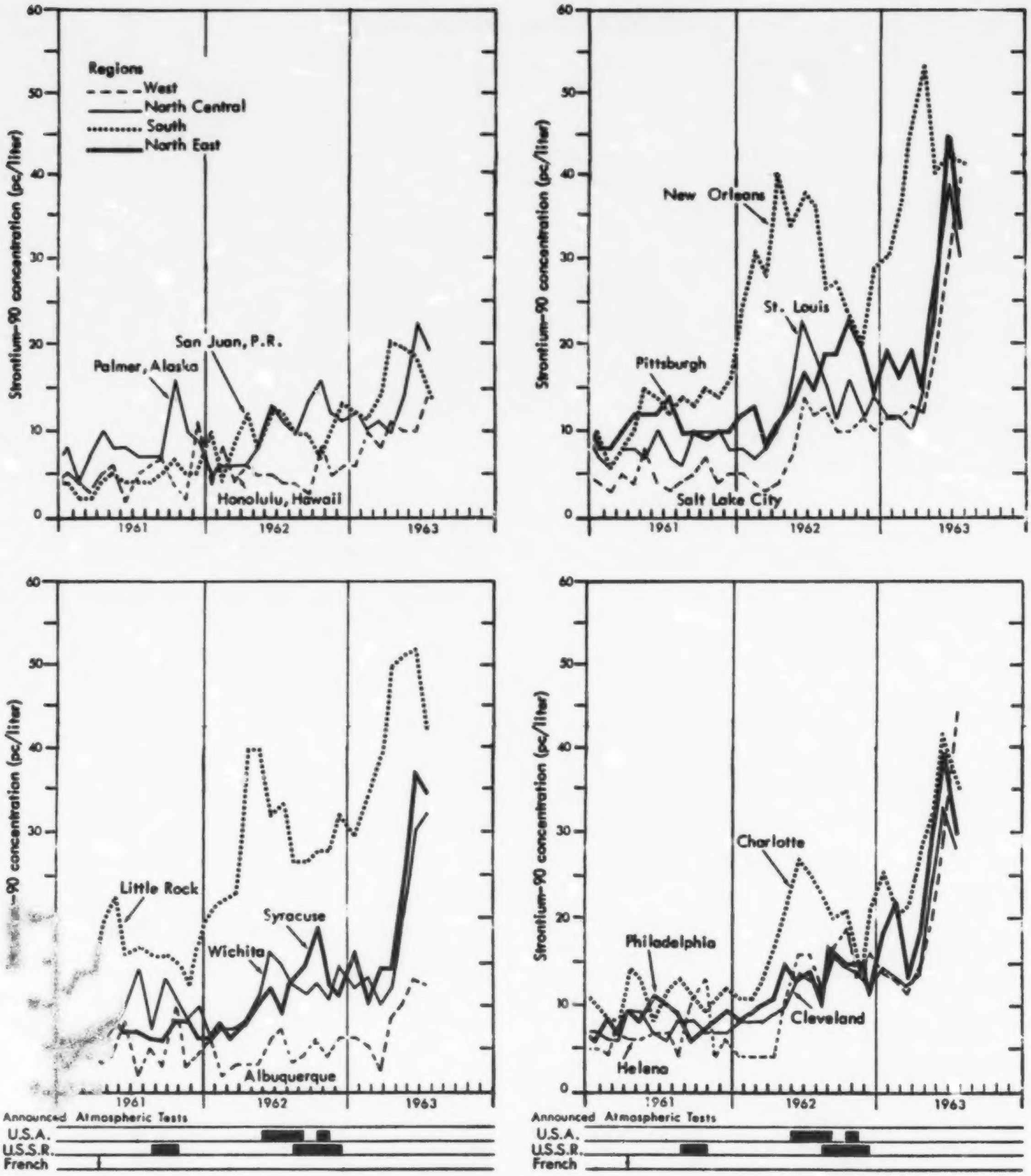

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

months. During July 48 stations had strontium-90 monthly averages of between 20 and 50 pc/liter; 10 stations had less than 20 pc/liter; four stations had 50 or more pc/liter.

The network average cesium-137 concentration in milk rose from 65 pc/liter in January to 165 pc/liter in July. Although the total range of the monthly station averages observed in July was from 15 to 380 pc/liter, 46 stations reported values below 200 pc/liter.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented (see figure 4). Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network at least twice a year.

REFERENCE

(*1*) Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291-6, Superintendent of Documents, Government Printing Office, Washington, 25, D.C. (June 1963).

INDIANA MILK NETWORK
July 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 6).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-140 are conducted on a weekly basis except when iodine-131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-[illegible] analyses are performed monthly on samples which are composited from weekly aliquots.

An ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

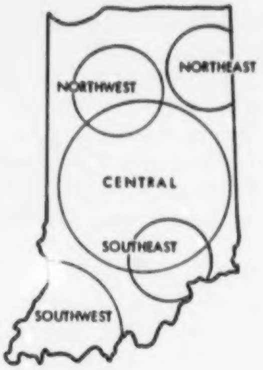

FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

TABLE 5.—RADIONUCLIDES IN INDIANA MILK, JULY 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	30	38	<10	120	<10
Southeast	60	60	<10	120	<10
Central	15	47	<10	115	<10
Southwest	30	57	<10	100	<10
Northwest	60	43	<10	145	<10
State average	40	49	<10	120	<10

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33:* 1306-8 (September 1961).

MINNESOTA MILK NETWORK
September 1962–June 1963

Division of Environmental Sanitation
Minnesota Department of Health

In September 1958, the Minnesota State Department of Health initiated a pasteurized milk surveillance network to monitor milk for strontium-90. The network presently consists of eight sampling stations (see figure 7). In October 1961 the collection of "grab" milk samples for iodine-131 analyses was started at these stations.

A two-ounce sample is collected daily at each station and is incorporated into a monthly composite sample analyzed for strontium-90. Collection is made at the pasteurizing plants' bottling machines so that the sample is randomly representative of the milk produced in that milkshed. The most recent strontium-90 data are shown in table 6.

One-liter samples are collected weekly for iodine-131 analyses. The minimum detectable concentration of iodine-131 in milk is 10 pc/liter. The monthly average is an arithmetic average of all samples collected within a given month. These monthly averages are shown in table 7. A value of 5 pc/liter is used when averaging values which are reported as <10 pc/liter. If the calculated monthly average is below 10 pc/liter, then the monthly average is reported as <10 pc/liter.

Analytical Procedure

Strontium-90 in milk is determined after ashing the evaporated residue from an 800-ml sample. Calcum and strontium are precipitated as oxalates from the ash. The separated oxalates are destroyed and the resulting solution scavenged with yttrium and barium. Yttrium-90 is allowed to ingrow and is then precipitated. This precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

Iodine-131 is determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. The counts in the iodine-131 photopeak which occur because of background and scatter from other gamma-emitting nuclides in milk are subtracted from the total. The value to be subtracted is empirically determined, and is based on the slope of the spectrum in this area and the magnitude of the counts in the channels adjacent to the photopeak.

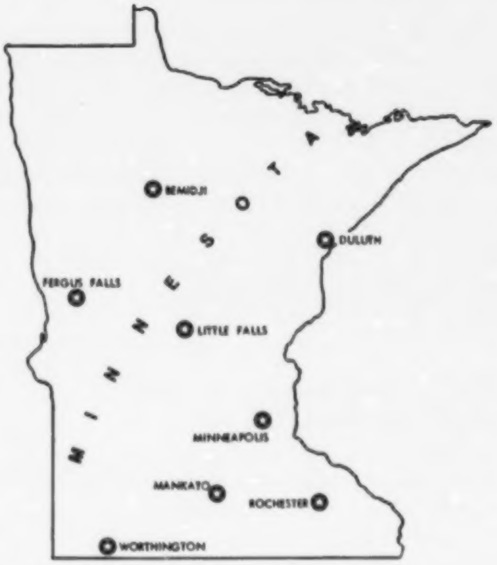

FIGURE 7.—MINNESOTA MILK SAMPLING LOCATIONS

TABLE 6.—STRONTIUM-90 IN MINNESOTA MILK, SEPTEMBER 1962—JUNE 1963

[Concentrations in pc/liter]

Sampling location	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bemidji	21.8	21.2	25.0	21.0	23.8	24.0	29.0	34.0	45.0	61.0
Duluth	26.9	24.6	26.9	23.0	27.6	18.0	27.0	30.0	35.0	65.0
Fergus Falls	21.9	20.5	22.1	15.0	13.3	16.0	19.0	16.5	28.0	41.0
Little Falls	26.4	14.2	20.0	15.0	13.3	21.0	19.0	21.0	40.0	45.0
Mankato	12.2	12.4	36.3	11.4	14.7	8.2	12.3	15.5	12.0	41.0
Minneapolis	17.7	16.8	26.3	17.0	22.0	21.0	19.0	20.0	32.0	48.0
Rochester	12.7	14.8	[a]—	—	12.9	13.0	16.0	14.7	21.0	26.0
Worthington	16.4	—	16.4	—	13.2	15.0	16.0	13.3	16.0	33.0
Average	19.5	17.8	24.7	17.1	17.6	15.8	19.7	20.6	28.6	45.0

[a] Dash indicates no sample.

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TABLE 7.—MONTHLY AVERAGE IODINE-131 IN MINNESOTA MILK, SEPTEMBER 1962—JUNE 1963

[Average concentrations in pc/liter]

Sampling location	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bemidji	172	93	25	17	25	<10	<10	29	<10	11
Duluth	176	129	38	16	22	12	<10	43	28	15
Fergus Falls	144	99	46	<10	17	22	<10	24	12	<10
Little Falls	167	84	53	20	14	17	<10	18	19	<10
Mankato	107	69	44	18	16	16	<10	38	19	<10
Minneapolis	90	73	79	14	13	15	<10	30	17	<10
Rochester	66	87	[a]—	17	29	32	<10	30	10	<10
Worthington	138	141	74	16	31	<10	<10	35	20	<10
Average	133	97	51	15	21	16	<10	31	16	<10

[a] Dash indicates no sample.

The trend is upward for strontium-90 in Minnesota milk. The State average ranged between 15.8 and 24.7 pc/liter from September 1962 through April 1963. In May 1963 the average increased to 28.6 pc/liter and then rose to 45 pc/liter in June 1963. Bemidji and Duluth, the Northernmost stations, have consistently had higher strontium-90 concentrations in milk. The highest monthly average strontium-90 concentration occurred in Duluth in June 1963 when a value of 65 pc/liter was noted.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
December 1960—April 1961	*October 1961*
October—December 1961 (iodine-131 data)	*March 1962*
May—December 1961 (strontium-90 data)	*August 1962*
March—September 1962	*April 1963*

NEW YORK MILK NETWORK
June 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 8), are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

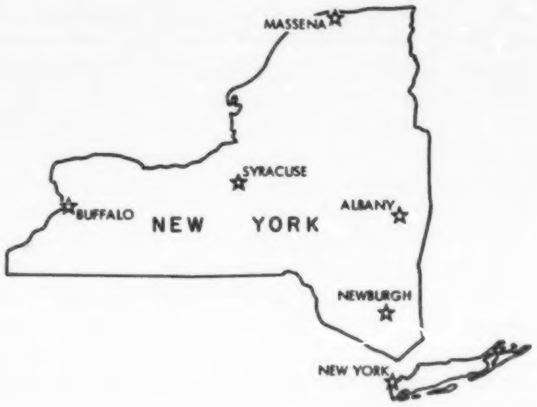

FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 8.

TABLE 8.—RADIONUCLIDES IN NEW YORK MILK, JUNE 1963

[Average concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$
Albany	75	21	<20	92	<20
Buffalo	48	16	<20	74	<20
Massena	76	16	<20	160	<20
Newburgh	81	30	<20	108	<20
New York City	113	31	<20	135	<20
Syracuse	91	27	<20	95	<20
Average	81	24	<20	111	<20

Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

REFERENCE

(1) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999-R-2*, (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education and Welfare, Washington, D.C. 20201.

CANADIAN MILK NETWORK [1]
July 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, the analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89 and cesium-137, as well as strontium-90.

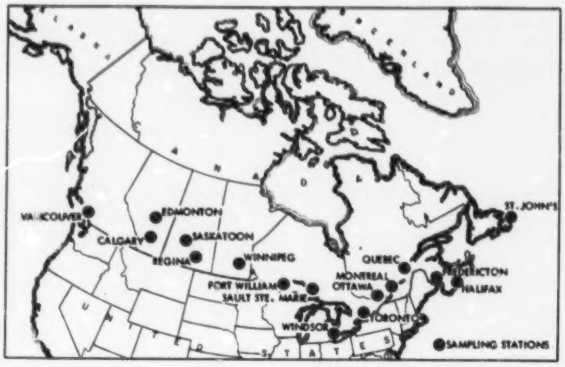

FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa for analysis. The contribution of each dairy to the composite sample is directed proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Iodine-131 is determined on a portion of each sample; the remaining portion is combined into monthly composites for the determination of strontium-90, strontium-89 and cesium-137.

Analytical Methods

For the analysis of iodine-131, radiochemical methods (*1*) are used. Carrier iodide is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to iodine and extracted with carbon tetrachloride, back-extracted in sulphite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine-131 determined by comparison with standard preparations.

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[1] Data from *Radiation Protection Programs, Vol. 1, No. 8:* 19-21, Radiation Protection Division, Canadian Department of National Health and Welfare (August 1963).

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with a polyethylene sheet. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium is separated on an ion-exchange column (*2, 3*). The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter isotope, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray, constructed in the form of an inverted well to accommodate the 5 x 4 inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier". In the determination of cesium this factor is not involved.

The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are shown in table 9 (all errors are 2σ values, representing 95 percent confidence level).

Results

Table 10 presents the results of the measurements on strontium–89, strontium–90, cesium–137,

TABLE 9.—TOTAL PERCENTAGE ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Iodine-131	50	20	10
Strontium-90	15	10	10
Strontium-89	25	20	15
Cesium-137	60	25	10

TABLE 10.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JULY 1963

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137
Calgary	1.37	214.9	74.1	8	309
Edmonton	1.29	143.3	53.1	1	278
Ft. William	1.34	127.7	52.9	6	296
Fredericton	1.35	132.7	54.1	2	322
Halifax	1.31	106.2	50.5	0	280
St. John's, Nfld	1.27	155.9	75.1	2	382
Montreal	1.32	97.6	46.3	2	183
Ottawa	1.25	96.5	34.0	6	227
Quebec	1.28	121.0	43.9	1	229
Regina	1.30	134.4	46.3	4	180
Saskatoon	1.35	124.5	40.3	4	178
Sault Ste. Marie	1.25	104.7	40.2	3	231
Toronto	1.33	44.1	16.6	3	84
Vancouver	1.40	150.9	51.9	2	393
Windsor	1.32	44.0	16.9	5	69
Winnipeg	1.28	121.7	46.4	3	178
Average	1.31	120.0	46.4	3	239

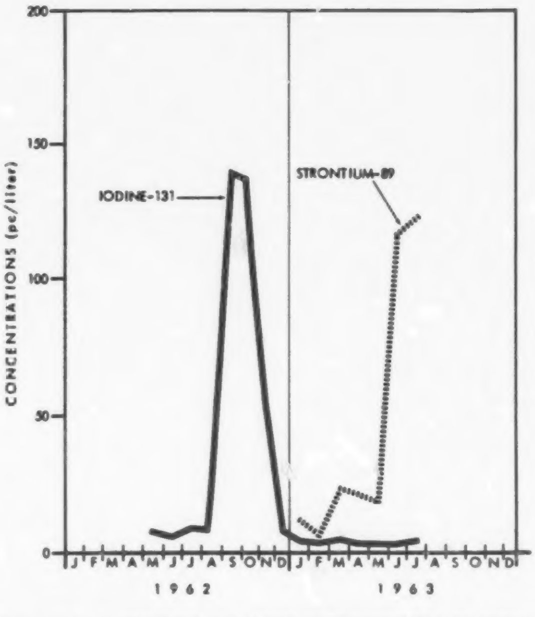

FIGURE 10.—IODINE–131 AND STRONTIUM–89 CONCENTRATIONS IN CANADIAN WHOLE MILK

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iodine-131, and stable calcium in Canadian whole milk for July. Figures 10 and 11 show the time profiles of the network average of the radionuclides in Canadian whole milk.

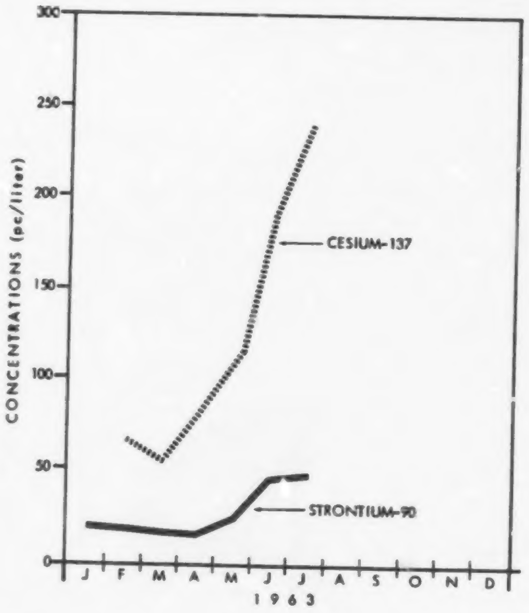

FIGURE 11.—STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*4*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23*, (October 1963).

(*2*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July 1958).

(*3*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare, (June 1, 1960).

(*4*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

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ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK

August 1962–July 1963

Utilization of the radionuclide concentration values reported by the Pasteurized Milk Network (*1*) for assessing that portion of an individual's or a population's radiation dose attributable to milk consumption is dependent on determining both the annual average concentrations of specific radionuclides of interest in milk and the average daily milk intake of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average

TABLE 1.—ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Iodine-131		Strontium-89		Strontium-90	
		July 1962–June 1963	August 1962–July 1963	July 1962–June 1963	August 1962–July 1963	July 1962–June 1963	August 1962–July 1963
Ala:	Montgomery	17	17	65	66	17	18
Alaska:	Palmer	102	102	55	56	13	14
Ariz:	Phoenix	11	<10	20	19	4	4
Ark:	Little Rock	38	38	132	135	36	37
Calif:	Sacramento	12	11	41	42	7	8
	San Francisco	13	11	72	74	11	11
Colo:	Denver	17	18	32	30	13	13
Conn:	Hartford	21	20	26	28	14	16
Del:	Wilmington	31	31	40	42	19	20
D. C:	Washington	23	23	46	47	18	19
Fla:	Tampa	18	18	35	36	12	12
Ga:	Atlanta	24	23	86	91	22	23
Hawaii:	Honolulu	12	12	36	37	7	8
Idaho:	Idaho Falls	23	19	41	46	14	17
Ill:	Chicago	33	30	29	31	16	17
Ind:	Indianapolis	30	29	40	41	18	19
Iowa:	Des Moines	47	43	79	78	18	19
Kans:	Wichita	31	27	57	56	15	16
Ky:	Louisville	26	26	97	102	26	27
La:	New Orleans	28	27	148	150	34	34
Maine:	Portland	22	22	32	35	20	21
Md:	Baltimore	23	23	48	52	18	19
Mass:	Boston	21	21	35	39	22	25
Mich:	Detroit	35	34	28	28	16	17
	Grand Rapids	26	25	24	26	14	15
Minn:	Minneapolis	32	30	64	64	23	24
Miss:	Jackson	26	25	145	148	27	28
Mo:	Kansas	45	41	93	90	20	21
	St. Louis	27	24	61	61	17	18
Mont:	Helena	36	34	54	54	16	19
Nebr:	Omaha	44	39	67	65	18	20
Nev:	Las Vegas	14	<10	22	22	6	7
N. H:	Manchester	21	21	35	37	20	23
N. J:	Trenton	22	22	31	32	16	18
N. Mex:	Albuquerque	16	14	25	25	6	7
N. Y:	Buffalo	23	22	28	31	17	18
	New York	30	30	34	37	18	21
	Syracuse	25	24	31	34	16	18
N. C:	Charlotte	<10	<10	67	72	25	26
N. Dak:	Minot	38	35	79	83	30	33
Ohio:	Cincinnati	38	36	50	52	20	21
	Cleveland	30	30	31	33	16	18
Okla:	Oklahoma City	34	33	78	70	21	21
Ore:	Portland	24	23	107	111	20	21
Pa:	Philadelphia	29	28	35	38	19	20
	Pittsburgh	38	37	40	44	21	22
P. R:	San Juan[1]	15	15	86	87	13	13
R. I:	Providence	22	22	32	35	18	21
S. C:	Charleston	20	19	70	72	23	23
S. Dak:	Rapid City	39	35	67	71	21	24
Tenn:	Chattanooga	20	20	108	116	27	28
	Memphis	27	27	102	105	26	26
Tex:	Austin	30	30	37	39	8	8
	Dallas	49	49	91	92	19	19
Utah:	Salt Lake City	88	43	38	39	14	16
Vt:	Burlington	23	23	34	37	17	19
Va:	Norfolk	17	17	56	56	21	21
Wash:	Seattle	26	23	74	77	18	20
	Spokane	26	20	50	53	17	19
W. Va:	Charleston	17	16	74	76	25	26
Wis:	Milwaukee	38	36	27	29	13	14
Wyo:	Laramie	51	23	66	62	16	18

[1] Average is for 48 weeks (No sample was received in November 1962).

concentrations of strontium–89, strontium–90 and iodine–131 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk intake (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

Employing an assumption, that the average daily milk consumption of an individual in a population group is one liter, permits comparisons to be made between the daily rates of intake of the above radionuclides from the milk component of the diet and the Federal Radiation Council's action ranges of transient daily rates of intake (*4*). The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*)[1]. The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Table 1, consisting of annual averages of radionuclide concentrations in milk, is based on the PHS Pasteurized Milk Network monthly averages of these radionuclides. To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values, (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in 12 consecutive months are averaged to obtain the annual average.

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method therefore shows trends over a considerable period of time.

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(*1*) Public Health Service: Pasteurized Milk Network, *Radiological Health Data*, 4:551–7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (November 1963).

(*2*) Bureau of the Census, Department of Commerce, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data*, 4:15–17, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962, *Radiological Health Data*, 4:124–7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, 3:ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 1962).

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[1] Upper limit of Range II corresponds to a dose of one-third of the annual RPG in the case of radioactive strontium.

SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
May 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 127 stations as of October 1963 (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically and radiologically. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).

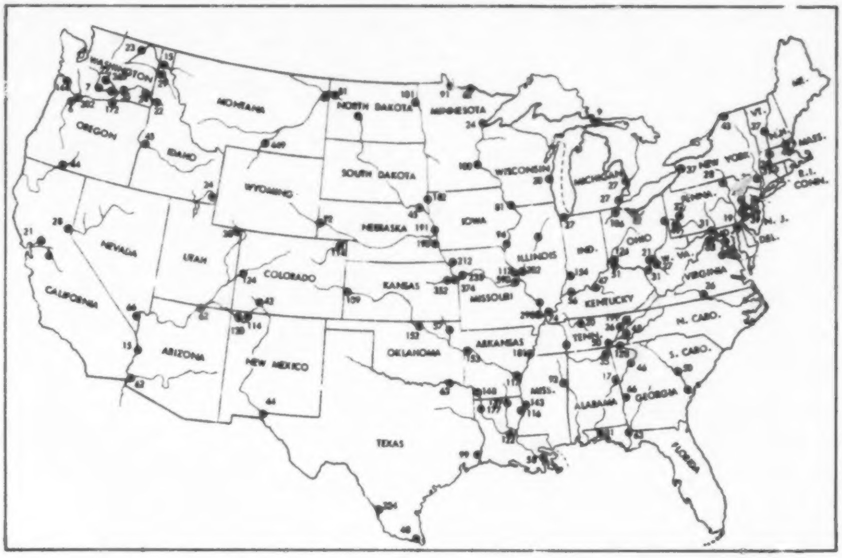
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
IND.
OHIO
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
MISS.
ALABAMA
GEORGIA
FLORIDA
KENTUCKY
TENN.
VIRGINIA
W. VA.
N. CARO.
S. CARO.
PENNA.
NEW YORK
N. J.
DEL.
VT.
N.H.
MASS.
R.I.
CONN.
ME.

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, MAY 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, MAY 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	7	15	22	0	0	0
Animas River: Cedar Hill, N. Mex	72	42	114	5	1	6
Apalachicola River: Chattahoochee, Fla	35	28	63	<1	0	<1
Arkansas River						
Coolidge, Kans	11	98	109	<1	25	25
Ponca City, Okla	68	84	152	1	2	3
Fort Smith, Ark	89	64	153	10	1	11
Pendleton Ferry, Ark	57	60	117	3	4	7
Bear River: Preston, Idaho	0	24	24	0	0	0
Big Horn River: Hardin, Mont	396	53	449	56	8	64
Big Sioux River: Sioux Falls, S. Dak	67	115	182	2	3	5
Chattahoochee River						
Atlanta, Ga	32	14	46	2	0	2
Columbus, Ga	38	28	66	1	0	1
Lanett, Ala	3	14	17	0	0	0
Clearwater River: Lewiston, Idaho	8	14	22	0	0	0
Clinch River						
Clinton, Tenn	10	16	26	0	<1	<1
Kingston, Tenn	47	152	199	1	1	2
Colorado River						
Loma, Colo	70	54	124	5	5	10
Page, Ariz	2	60	62	0	6	6
Boulder City, Nev	5	61	66	0	9	9
Parker Dam, Calif-Ariz	0	15	15	1	7	8
Yuma, Ariz	2	60	62	0	5	5
Columbia River						
Northport, Wash	6	17	23	0	0	0
Wenatchee, Wash	6	16	22	0	1	1
Pasco, Wash	74	286	360	1	1	2
McNary Dam, Ore	40	132	172	0	<1	<1
Bonneville, Ore	76	126	202	0	1	1
Clatskanie, Ore	47	97	144	0	0	0
Cumberland River: Clarksville, Tenn	6	14	20	0	0	0
Connecticut River						
Wilder, Vt	9	28	37	0	0	0
Northfield, Mass	13	25	38	0	0	0
Enfield Dam, Conn	12	19	31	0	0	0
Cuyahoga River: Cleveland, Ohio	16	66	82	<1	1	1
Delaware River						
Martins Creek, Pa	7	22	29	0	0	0
Trenton, N. J	42	23	65	0	1	1
Philadelphia, Pa	19	30	49	1	1	2
Escambia River: Century, Fla	16	15	31	0	0	0
Great Lakes						
Duluth, Minn	7	17	24	0	0	0
Sault Ste, Marie, Mich	2	7	9	0	0	0
Milwaukee, Wisc	2	18	20	0	1	1
Gary, Ind	8	19	27	0	0	0
Port Huron, Mich	9	18	27	0	0	0
Detroit, Mich	8	19	27	0	0	0
Buffalo, N. Y	14	23	37	0	1	1
Green River: Dutch John, Utah	0	38	38	0	3	3
Hudson River: Poughkeepsie, N. Y	10	22	32	0	0	0
Illinois River: Grafton, Ill	43	74	117	2	0	2
Kanawha River: Winfield Dam, W. Va	9	18	27	0	0	0
Klamath River: Keno, Ore	13	31	44	0	0	0
Kansas River: De Soto, Kans	255	97	352	4	1	5
Maumee River: Toledo, Ohio	29	77	106	<1	1	1
Little Miami River: Cincinnati, Ohio	54	70	124	1	0	1
Merrimack River: Lowell, Mass	13	35	48	0	0	0
Mississippi River						
St. Paul, Minn	31	69	100	0	2	2
Dubuque, Iowa	30	51	81	1	1	2
Burlington, Iowa	45	49	94	0	0	0
E. St. Louis, Ill	134	68	202	9	2	11
Cape Girardeau, Mo	233	65	298	6	4	10
W. Memphis, Ark	142	39	181	3	0	3
Vicksburg, Miss	98	45	143	1	1	2
Delta, La	77	39	116	7	1	8
New Orleans, La	20	38	58	1	0	1
Missouri River						
Williston, N. Dak	24	57	81	2	4	[illegible]
Yankton, S. Dak	8	37	45	0	6	[illegible]
Mo. River—Cont.						
Omaha, Nebr	152	39	191	5	2	7
St. Joseph, Mo	158	54	212	5	2	7
Kansas City, Kans	318	56	374	32	8	40
Missouri City, Mo	194	44	238	21	2	23
St. Louis, Mo	524	66	590	35	2	37
Monongahela River: Pittsburgh, Pa	0	49	49	0	1	1
North Platte River: Henry, Nebr	29	63	92	<1	17	17
Ohio River						
Addison, Ohio	2	19	21	0	0	0
Huntington, W. Va	13	18	31	0	1	1
Cincinnati, Ohio	19	32	51	0	0	0
Louisville, Ky	17	30	47	0	0	0
Evansville, Ind	24	32	56	1	1	2
Cairo, Ill	34	40	74	5	<1	5
Ouachita River: Bastrop, La	71	68	139	2	1	3
Pend Oreille River: Idaho	8	7	15	0	0	0
Platte River: Plattsmouth, Nebr	115	75	190	4	3	7
Potomac River						
Williamsport, Md	8	23	31	0	0	0
Great Falls, Md	7	21	28	0	0	0
Rainy River						
Baudette, Minn	32	59	91	1	0	1
International Fls, Minn	14	48	62	0	0	0
Red River, North:						
Grand Forks, N. Dak	19	82	101	1	3	4
Red River, South						
Denison, Tex	16	47	63	1	0	1
Index, Ark	87	61	148	2	1	3
Bossier City, La	125	52	177	3	0	3
Alexandria, La	74	48	122	4	1	5
Rio Grande River						
Alamosa, Colo	16	26	42	0	2	2
El Paso, Tex	12	32	44	0	5	5
Laredo, Tex	256	68	324	14	1	15
Brownsville, Tex	17	31	48	0	3	3
Roanoke River: John H. Kerr Resr. & Dam Va	12	14	26	1	0	1
Sabine River: Ruliff, Tex	47	52	99	2	1	3
Sacramento River: Courtland, Calif	13	8	21	0	0	0
San Juan River: Shiprock, N. Mex	85	35	120	16	4	20
St. Lawrence River: Massena, N. Y	17	26	43	0	1	1
Schuylkill River: Philadelphia, Pa	10	29	39	0	0	0
Savannah River: North Augusta, Ga	31	19	50	0	0	0
Shenandoah River: Berryville, Va	19	14	33	0	0	0
Ship Creek: Anchorage, Alaska	13	22	35	0	0	0
Snake River:						
Ice Harbor Dam, Wash	6	18	24	0	1	1
Wawawai, Wash	21	14	35	0	1	1
Payette, Idaho	20	25	45	0	1	1
South Platte River: Julesburg, Colo	19	95	114	<1	32	32
Spokane River: Post Falls, Idaho	15	14	29	1	0	1
Susquehanna River						
Sayre, Pa	14	14	28	0	0	0
Conowingo, Md	5	14	19	0	0	0
Tennessee River						
Lenoir City, Tenn	20	28	48	<1	0	<1
Chattanooga, Tenn	76	52	128	2	0	2
Bridgeport, Ala	12	23	35	0	0	0
Pickwick Landing, Tenn	21	29	50	0	<1	<1
Tombigbee River: Columbus, Miss	69	24	93	1	1	2
Truckee River: Farad, Calif	14	14	28	0	0	0
Verdigris River: Nowata, Okla	6	51	57	0	0	0
Wabash River: New Harmony, Ind	96	58	154	4	1	5
Willamette River: Portland, Ore	0	6	6	0	0	0
Yakima River: Richland, Wash	2	5	7	0	0	0
Maximum	524	286	590	56	32	64
Minimum	0	5	6	0	0	0

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[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data* (6).

A one-liter "grab" sample is collected weekly by personnel of the participating agencies and shipped to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Since that time a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents May 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of this report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957-1962 have been summarized by Weaver *et al* (*9*).

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RADIOACTIVITY IN MINNESOTA SURFACE WATER

December 1962–June 1963

Division of Environmental Sanitation,
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but 7 surface streams and lakes involving 9 stations are now sampled routinely (see figure 2). "Grab" samples of raw treated water are collected weekly at each station with the exception of the Crookston International Falls, and St. Cloud stations, where monthly samples are collected.

The samples are forwarded to the Division's Laboratory where they are analyzed for gross beta activity. A 250-ml sample of water is evaporated at 75°C. from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with either an internal proportional counter or a thin end window proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

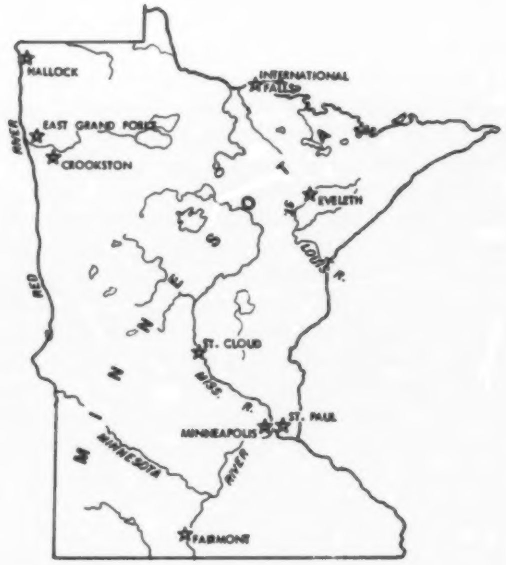

FIGURE 2.—SURFACE WATER SAMPLING LOCATIONS

Table 2 shows the monthly average gross beta activity in Minnesota surface water from December 1962 through June 1963. The minimum de-

TABLE 2.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, DECEMBER 1962—JUNE 1963

[Monthly average concentrations in pc/liter]

Town (Water source)	Type of water	Dec	Jan	Feb	Mar	Apr	May	Jun
Crookston, (Red Lake River)	Raw	—[a]	—	—	15	51	120	75
	Treated	—	—	—	15	36	72	75
East Grand Forks, (Red Lake River)	Raw	30	20	21	40	164	83	100
	Treated	21	15	20	26	82	45	46
Eveleth, (St. Mary's Lake)	Raw	20	21	34	29	28	51	90
	Treated	17	32	24	33	36	55	41
Fairmont, (Budd Lake)	Raw	32	20	19	56	56	50	54
	Treated	15	16	32	29	30	39	19
Hallock, (Two Rivers South Fork)	Raw	53	36	49	61	164	117	130
	Treated	22	20	24	33	97	48	44
International Falls, (Rainy River)	Raw	—	46	—	25	42	70	41
	Treated	—	15	—	25	40	75	16
Minneapolis, (Tap Water)	Raw	—	—	—	—	—	—	—
	Treated	—	16	16	17	51	31	29
St. Cloud, (Mississippi River)	Raw	—	15	—	15	120	107	63
	Treated	—	15	—	15	39	35	51
St. Paul, (Vadnais Chain of Lakes)	Raw	30	24	24	50	57	63	83
	Treated	21	57	19	32	45	28	63

[a] Dash indicates no analysis performed.

tectable level is a convenient low value not normally exceeded by one standard deviation; this is at present 15 pc/liter. In averaging, the value 15 pc/liter is used for samples having this concentration or less. The two-standard-deviation counting error for a majority of analyses of individual samples ranges from 19 to 25 pc/liter.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 15 to 164 pc/liter. Individual samples had concentrations that ranged from <15 to 280 pc/liter.

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SECTION IV.—OTHER DATA

Strontium-90 in Human Vertebrae, March 1962—March 1963[1]

Joseph Rivera[2]

In *HASL-127* (*1*), data were presented on the strontium-90 content of human vertebrae collected from March 1961 to February 1962 at New York City, Chicago and San Francisco.

This report contains similar data on the results of analyses of samples collected from March 1962 to March 1963. The purpose of these studies is to establish more quantitatively the relation between strontium-90 and calcium levels in the diet and in bone, and also to continue the documentation of strontium-90 levels in human bone in this country.

During the period March 1962 to March 1963, 402 bone specimens were obtained. Of these, 215 were considered suitable to be analyzed singly or as part of composite samples. Analyses were performed on 165 vertebrae and 25 other samples which were part of the quality control program.

Results of the analyses are presented in table 1. A summary of previous results obtained in the HASL bone studies is given in table 2.

From tables 1 and 2 it is apparent that the levels strontium-90 in the bones obtained in 1963 were generally higher than those obtained in 1962. The variation of levels with age is similar to that seen in 1962 and in previous years by Kulp and Schulert (*2*) and Bryant and Loutit (*3*).

As was expected from the diet levels (*4*), highest strontium-90 levels were found in bones from New York City, lowest values were seen in bones from San Francisco, and intermediate values were generally found in bones obtained in Chicago.

Infants (0–1 year)

From measurements of the stable strontium concentrations in the diet and bones of children from 0 to 1 year old, the bone/diet observed ratios were 0.31, using data from New York City and San Francisco (*5*). The predicted values of the Sr^{90}/Ca ratio of the bones of six-month-old children in 1963 should, therefore, be approximately 0.31 times the estimated Sr^{90}/Ca ratio of their diet. This is an approximation, since no account has been taken of the degree to which the infants are in equilibrium with their diet.

An estimate of how close the bone levels are in equilibrium with the diet as far as strontium is concerned may be made by comparing the specific activity (pc Sr^{90}/mg Sr) of bone with that of the diet. In New York City, the calculated specific activity of the bones of six-month-old children was 20 pc/mg, while the diet had a specific activity of 24 pc/mg. In San Francisco the values were 3.2 pc/mg in bone and 5.3 pc/mg in the diet. From these values one may conclude that the New York City infants had 80 percent of their skeletons formed with a Sr^{90}/Ca ratio of 0.31 times the Sr^{90}/Ca ratio of their diet, and 20 percent of their

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[1] Summarized from *Fallout Program Quarterly Summary Report, HASL-138*:239-48, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1963), price $3.50.

[2] Mr. Rivera is a physicist on the Staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

TABLE 1.—STRONTIUM-90 IN HUMAN VERTEBRAE, MARCH 1962—MARCH 1963

[Concentrations in pc/g Ca]

Age at death (years)	New York		Chicago		San Francisco	
	Number of samples[a]	Average[b]	Number of samples[a]	Average[b]	Number of samples[a]	Average[b]
0–1	16	3.81 ±1.26	0		26	1.07 ±0.34
1–2	8	3.29 ±1.17	1	2.32	2	1.27 ±0.50
2–3	4	2.68 ±0.90	0		6	1.53 ±0.63
3–4	9	2.62 ±0.68	1	0.68	5	1.18 ±0.36
4–5	3	1.94 ±0.25	1	1.06	4	1.15 ±0.84
5–6	0		2	1.68 ±0.44	3	0.63 ±0.17
6–7	1	1.81	1	1.49	3	1.10 ±0.24
7–8	1	1.65	0		3	0.92 ±0.17
8–9	4	1.57 ±0.23	0		0	
9–10	2	1.69 ±0.31	1	1.43	1	0.51
10–12	0		2	0.81	1	0.41
12–14	4	1.81 ±0.74	2	1.08 ±0.49	1	1.0
14–16	2	1.54 ±0.07	2	1.50 ±0.39	3	1.00 ±0.19
16–18	6	2.36 ±1.63	1	1.51	1	0.97
18–20	6	1.73 ±0.40	0		3	0.92 ±0.36
20–40	6	1.01 ±0.06	18	0.81 ±0.42	5	0.94 ±0.29
40–60	3	0.61 ±0.04	26	0.69 ±0.24	3	0.45 ±0.10
over 60	5	1.04 ±0.04	6	1.62 ±0.19	1	0.59

[a] Individual sample values may be found in *HASL-138* (see footnote 1, page 570).

[b] ± values indicate one standard deviation of samples from the mean values.

TABLE 2.—STRONTIUM-90 IN HUMAN VERTEBRAE, MARCH 1961—MARCH 1962

[Concentration in pc/g Ca]

Age at death (years)	New York		Chicago		San Francisco	
	Number of samples	Average[a]	Number of samples	Average[a]	Number of samples	Average[a]
0–1	8	3.43 ±1.50	1	1.40	10	0.49 ±0.09
1–2	5	2.67 ±0.26			3	0.79 ±0.52
2–3	2	2.34 ±0.32				
3–4	5	2.05 ±0.82	1	2.26	4	1.33 ±0.19
4–5	4	1.74 ±0.54	3	2.08 ±0.18	2	2.15 ±1.63
5–6	1	1.51				
6–7	5	1.37 ±0.46				
7–8	3	1.62 ±0.49			2	0.52 ±0.10
8–9					1	0.78
9–10	2	1.20 ±0.44			4	1.18 ±0.04
10–12	2	1.55 ±0.64	2	1.37 ±0.45	2	0.62 ±0.04
12–14	2	0.62 ±0.64	2	1.03	1	0.67
14–16	3	1.16 ±0.34	2	1.37 ±0.04	1	1.68
16–18	6	1.44 ±0.28	1	1.36		
18–20	11	1.08 ±0.20	3	0.48 ±0.33		
20–40	16	1.05 ±0.51	10	0.57	15	0.50 ±0.13
40–60	10	0.63 ±0.05	20	0.44 ±0.04	15	0.46 ±0.06
over 60	5	0.69	9	0.76	15	0.50 ±0.09

[a] Individual sample values may be found in *HASL-138* (see footnote 1, page 570).

skeletons with a Sr^{90}/Ca ratio proportional to the Sr^{90}/Ca ratio of the diet of their mothers. In San Francisco these relative fractions were 60 and 40 percent. Using the currently accepted proportionality factor of 0.1 for the fetal bone-mother's diet observed ratio, and the Sr^{90}/Ca ratio of the mother's diet during the period of gestation, a more refined prediction of the Sr^{90}/Ca ratios in infant's bones can be made. These predictions and corresponding observed values are given in table 3.

Children (1.5–4.5 years)

Calculation of bone strontium-90 levels at different ages may be accomplished by considering the following equation, which is a simplified version of that given by Kulp:

$$Ca_nX_n = Ca_{n-1}X_{n-1} + [Ca_n - Ca_{n-1}]ZK + [KZ - X_{n-1}]F\,Ca_{n-1}$$

Ca_n is the calcium content of the bones of the 'n' years old in 1962.

X_n is the Sr^{90}/Ca ratio of the bones of the 'n' years old in 1962.

X_{n-1} is the Sr^{90}/Ca ratio of 'n–1' years old in 1961.

Z is the average Sr^{90}/Ca ratio of the diet from 10/61 to 9/62.

K is the diet-bone observed ratio appropriate to an individual of age between 'n–1' and 'n' years old.

F is the fraction of the skeleton exchanged during the year by an individual between 'n–1' and 'n' years old.

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TABLE 3.—PREDICTED AND OBSERVED STRONTIUM-90 IN INFANT BONES

[pc Sr^{90}/g Ca]

City and Dates	Diet	Predicted		Observed
		ratio = 0.31	ratio = 0.25	
New York City				
3/61–3/62	10.1	3.1		3.4 ± 1.5
10/61–9/62	11.6			
3/62–2/63	14.5	4.2	[a]3.8	3.8 ± 1.3
San Francisco				
3/61–2/62	3.4	1.1		0.5 ± 0.1
10/61–9/62	4.4			
3/62–2/63	5.6	1.5	[a]1.1	1.1 ± 0.3

[a] Corrected for lack of complete equilibrium.

The left hand term of the equation is the total strontium-90 burden of an individual 'n' years old. The first term on the right is the total strontium-90 burden the individual had one year previously. The second term is the strontium-90 accreted during the year, since it is the increase in calcium multiplied by the Sr^{90}/Ca ratio of 'new' bone, i.e., diet Sr^{90}/Ca X diet-bone observed ratio. The last term is the strontium-90 added or lost due to resorption of calcium with a concentration of strontium-90 characteristic of 'old' bone and its replacement by bone having a strontium-90 concentration characteristic of 'new' bone.

Average values of X_n and X_{n-1} determined for bone samples obtained from children up to the age of 5 years at death in New York City and San Franscisco were substituted above. Values of Ca_n and Ca_{n-1} taken from Mitchell *et al* (*6*) and the estimates of Z for New York City for the period October 1961–September 1962 were also inserted above. The result was 8 equations with K and F the only unknowns. Estimates of the values for K and F that best fit the observed data were made by plotting K against F and determining the coordinates of points of intersection of the curves within the region bounded by $K=0$ to $K=1$ and $F=0$ to $F=1$. All of the values for K of these points were within a very narrow range while the values of F varied considerably. The mean values and standard deviations for the points of intersection were:

$$F = 0.51 \pm 0.20 \qquad K = 0.24 \pm 0.01$$

An idea of how well these values "fit" the data can be had by comparing predicted and observed bone strontium-90 concentrations of New York City and San Francisco children who died in the summer of 1962, as follows in table 4:

TABLE 4.—COMPARISON OF PREDICTED VS OBSERVED STRONTIUM-90 LEVELS IN CHILDREN'S BONES

City	Age at death (years)	pc Sr^{90}/g Ca	
		Predicted	Observed
New York City	1.5	3.04	3.05
	2.5	2.80	2.68
	3.5	2.65	2.61
	4.5	2.50	1.93
San Francisco	1.5	0.90	1.27
	2.5	0.85	1.53
	3.5	1.18	1.18
	4.5	1.18	1.15

Adults (>20 years old)

It has been shown that a reasonable estimate of K for adults, based on stable strontium measurements of diet and bone is 0.16 (*5*). If this value is inserted above, and setting $Ca_n = Ca_{n-1}$ for adults, the estimates of F from the data from New York City and Chicago are:

$$\text{New York City, } F = 0.08$$
$$\text{Chicago, } F = 0.34$$

Data from San Francisco were not used because, as can be seen from table 2, the standard deviation from the mean of X_n for adults from San Francisco was very great.

Errors

The average relative error due to counting for the set of 165 bone samples analyzed was 8.9 percent. Sixteen percent of the samples had counting errors less than 6 percent, 77 percent had counting errors less than 11 percent, and 93 percent had counting errors less than 16 percent.

In addition to the 165 samples analyzed, 25 samples were analyzed as part of the quality control program in operation at the Laboratory. These samples included a very low level standard analyzed 8 times, a high level standard analyzed 7 times, a low level standard analyzed 4 times, and 6 of the set of 165 samples which were analyzed as blind duplicates. The average relative error due to counting for this set of analyses was 17 percent.

Conclusions

Based on measurements of the strontium-90 content of the diet for the last three years and measurements of the strontium-90 content of human vertebrae obtained for the last two years, it is concluded that the diet-bone observed ratio for children from 1 to 5 years old is about 0.24 and that the average annual exchange rate of their skeleton is about 51 percent. It is furthermore concluded that the diet-bone observed ratio for adult vertebrae is about 0.16 and that the annual exchange rate of vertebrae skeleton is about 8 percent. From specific activity calculations (Sr^{90}/Sr) in diet and bones of infants six months old, it is concluded that the exchange rate of the skeleton was from 60 to 80 percent. The diet-bone observed ratio of six-month-old infants may be higher than 0.25 but the data are not conclusive.

Only tentative conclusions could be reached, since they are based on a very limited number of samples taken at times of the year when diet levels of strontium–90 were changing greatly. It is hoped that more significant data will be available in the near future.

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Whole Body Counting

Whole body counters, utilizing high-pressure ionization chambers, liquid or plastic scintillators or thallium-activated sodium iodide crystals, are being applied to a number of problems of common interest to workers in the medical research and radiological health fields. Typical investigations involving whole body counting procedures include the rapid detection of low levels of gamma-emitting radionuclides, the identification of unknown radioactive contaminants, the monitoring of persons and foodstuffs, and the nondestructive, direct measurement of body potassium and low tracer doses of certain radionuclides in metabolic studies.

Cesium–137 measurements in residents of West Germany obtained by the U.S. Army Medical Research Unit, Landstuhl, Germany are reported below.

CESIUM–137 IN MAN
March–July 1963

U.S. Army Medical Research Unit,
Landstuhl, Germany

Cesium–137 was first detected in man at the Argonne National Laboratory in 1955 (*1*). This nuclide emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium–137 levels are usually expressed in picocuries per gram of potassium.

The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, utilizes a liquid scintillation counter in its program for measuring the cesium–137 levels in man (*2*). Results of analyses performed at Landstuhl from March through July 1963 are presented in table 1.

TABLE 1.—CESIUM–137 RESULTS OF WHOLE BODY COUNTING AT LANDSTUHL, MARCH—JULY 1963

Month	Number of subjects	Residence	Cesium-137 pc/g K (average)
March	211	West Germany	74
April	14	West Germany	84
May	298	West Germany	93
June	157	West Germany	90
July	187	West Germany	104

The values in table 1 represent an increase in body burden when compared with an average of 32 pc Cs^{137} per gram of potassium for March through July 1962. This increase tends to support recent predictions of average cesium–137 body burdens made by the Federal Radiation Council (*3*). Although the predictions were made strictly for the U.S., it can be assumed that they are generally applicable to West Germany.

The Federal Radiation Council has recommended (*4*) that the whole body dose to an individual in the general population be less than the Radiation Protection Guide (RPG) of 0.5 rem per year. It is recommended, further, that a population average whole body dose of 170 mrem per year not be exceeded. Also, The Council has stated (5) that the characteristics of cesium-137 lead to direct comparison of this nuclide with recommended whole body exposures. Calculations of the NCRP (*6*) indicate that a whole body burden for cesium-137 of 30,000 nc yields a whole body dose of 5 rem per year to an individual. Hence, an average body burden of 1000 nc may be taken as yielding a per capita whole body dose of 170 mrem per year to a suitable sample of the exposed population. If the highest value in table 1, 104 pc/gram potassium, is multiplied by 140 grams of potassium in a "standard man" (*7*), the resulting whole body burden, 15 nc, would yield about 1.5 percent of the appropriate RPG of 170 mrem.

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Recent Coverage in *Radiological Health Data*:

Period	*Issue*
First Quarter 1962	*August 1962*
Second Quarter 1962	*October 1962*
Third Quarter 1962	*December 1962*
July 1958—September 1962	*April 1963*
September—December 1962	*August 1963*

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. The environmental monitoring summary for the Atomics' International facility is presented below.

ATOMICS INTERNATIONAL
Calendar Year 1962

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops and constructs nuclear reactors for control station and compact power plants, and for medical, industrial, and scientific applications. Locations of the facilities are shown in figure 1.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building but a small amount of fuel fabrication is conducted there. For this reason, the WHF area in included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air Monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with

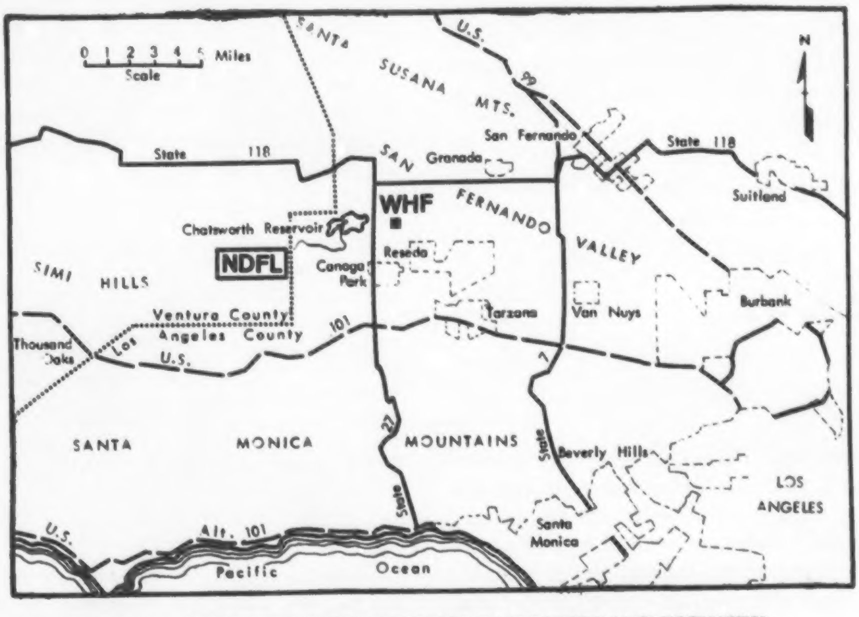
0 1 2 3 4 5 Miles
Scale
N
SANTA SUSANA MTS.
U.S. 99
San Fernando
State 118
State 118
Granada
SAN FERNANDO VALLEY
WHF
Sunland
Chatsworth Reservoir
NDFL
Canoga Park
Reseda
SIMI HILLS
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
101
U.S.
Thousand Oaks
7
SANTA MONICA MOUNTAINS
27
State
State
Beverly Hills
LOS ANGELES
U.S.
Alt. 101
Santa Monica
Pacific Ocean

FIGURE 1.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. The minimum detection limit is on the order of 0.02 pc/m³. Averages for beta-gamma activity in airborne particulates are given in table 1.

TABLE 1.—AIRBORNE BETA-GAMMA ACTIVITY AT ATOMICS INTERNATIONAL, CALENDAR YEAR 1962

[pc/m³]

Type of sample and minimum detection levels	Location	First half 1962		Second half 1962	
		No. of samples	Average concentration	No. of samples	Average concentration
Air (β-γ = 0.04 pc/m³)	WHF NDFL	163 148	8.5 6.3	180 166	6.2 4.9

Water Samples

Process water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 2). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth Reservoir are similarly obtained (see table 3).

TABLE 2.—NDFL WELL WATER MONITORING, 1962

[pc/liter]

Activity	First half		Second half	
	No. of samples	Average	No. of samples	Average
α	12	0.09 to 0.11	12	0.30 to 0.32
β-γ	12	3.1 to 3.2	12	20

In the laboratory, 500 ml. of water are evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred into stainless steel planchets, wetted to produce an even sample distribution, redried under infrared lamps, and counted in an automatic proportional counting system.

TABLE 3.—CHATSWORTH RESERVOIR WATER SAMPLING, 1962

[pc/liter]

Sample Type	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
Lake surface	α β-γ	21 21	0.46 to 0.47 20	20 20	0.88 17
Supply inlet	α β-γ	6 6	.50 12	6 6	0.50 14

Soil and Vegetation Samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as one-site stations. The remaining 38 stations are located within a 10-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top ½-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of drying the soil in a muffle furnace at 500°C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 4.

TABLE 4.—SOIL RADIOACTIVITY, 1962

[pc/gm]

Area	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
On site	α β-γ	69 69	0.40 to 0.42 43	78 78	0.44 to 0.46 52
Off site	α β-γ	227 227	0.31 to 0.38 42	226 226	0.39 to 0.44 53

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. The leaves are stripped from the plant and washed to remove foreign matter at the laboratory. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500°C. for approximately eight hours. This produces a completely oxidized ash of uniform density. Three hundred-milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 5.

TABLE 5.—VEGETATION RADIOACTIVITY, 1962

[pc/gm ash]

Area	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
On site	α	69	0.37 to 0.39	78	0.49 to 0.51
	β-γ	69	702	78	321
Off site	α	227	0.30 to 0.32	226	0.54 to 0.55
	β-γ	227	558	226	253

REPORTED NUCLEAR DETONATIONS

October 1963

Four nuclear detonations at the Nevada Test Site during October 1963 were announced by the Atomic Energy Commission.

The first two of these were low yield underground tests conducted on October 11, one of which was a weapons-related test and the other was a part of the Commission's Plowshare Program to develop peaceful uses for nuclear explosives.

On October 16, a test of intermediate yield was conducted underground at the Site. (Low yield range means less than 20 kilotons; intermediate yield range is from 20 kilotons to one megaton.)

On October 26, a nuclear explosion of about 12 kilotons yield took place 1,200 feet underground in a remote area about 28 miles southeast of the town of Fallon, Nevada. This test, called Project Shoal, was a part of the Department of Defense research program to improve systems for detecting and identifying underground nuclear explosions.

Arbitrary reference numbers assigned by *Radiological Health Data* to the four October tests are, in the order mentioned above, 139 to 142.

RADIOLOGICAL HEALTH DATA

VOLUME IV, NUMBER 12
DECEMBER 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more intensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air for August 1963 are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, and the Pan American Health Organization. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 4), which presents data on Canadian and U.S. gross beta radioactivity in air for August. To adjust the data from the two networks to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850,* Naval Research Laboratory, Washington, D.C. (November 13, 1962); abstracted in *Radiological Health Data,* December 1962.

RADIATION SURVEILLANCE NETWORK
August 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) is made up of 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State Health Department personnel.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter, 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower. Field estimates of gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}–Y^{90} standard source. Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = C$ (*1*)[1]. The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

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[1] In this expression, A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T = 1$.

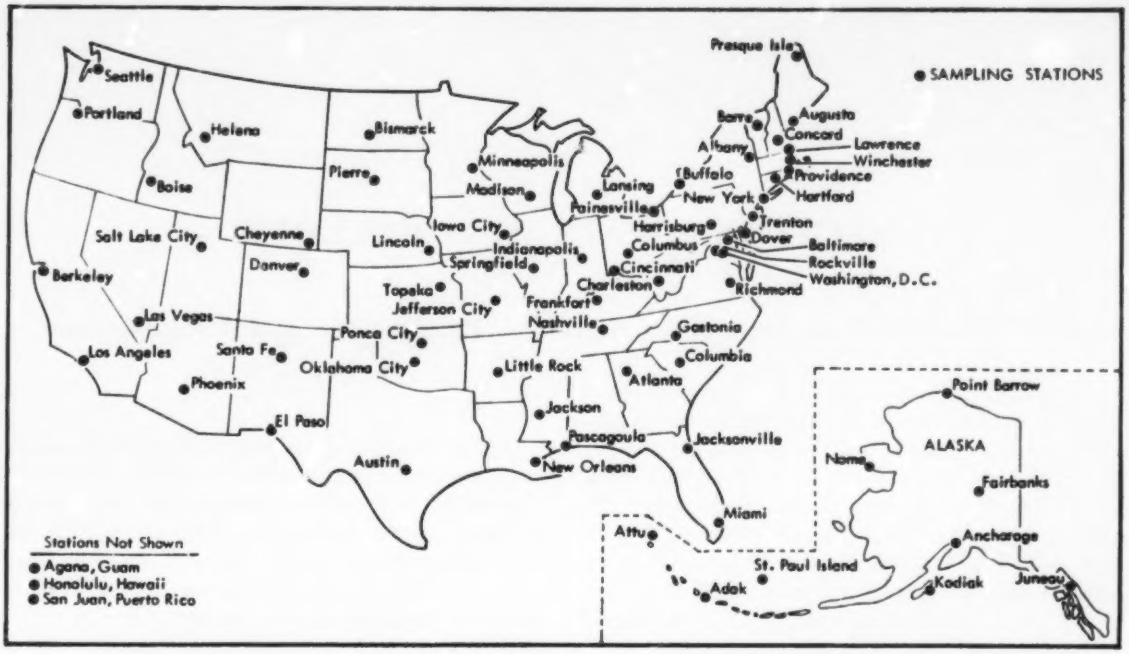
● SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Las Vegas
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Phoenix
El Paso
Austin
Little Rock
Jackson
Pascagoula
New Orleans
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Buffalo
Lansing
New York
Painesville
Trenton
Harrisburg
Dover
Columbus
Baltimore
Cincinnati
Rockville
Washington, D.C.
Charleston
Richmond
Frankfort
Nashville
Gastonia
Columbia
Atlanta
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, AUGUST 1963

The August 1963 average fission-product beta concentrations in surface air (extrapolated values) are given in table 1. RSN and Pan American data are adjusted by the intercalibration factor 1.54,[2] and presented with Canadian air data in the form of isogram lines in figure 4, which shows the distribution of fission product activity over those portions of North American where air monitoring networks are intercalibrated.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. August 1963 averages of gross beta activity in precipitation, expressed as picocuries per liter and as nanocuries per square meter, are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *RHD*. The profiles of 7 stations, through August 1963, are shown in figure 2.

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review*, 73:1318–30 (June 1, 1948).
(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (Distribution by official request).

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[2] See reference (*1*) on page 579.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, AUGUST 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in *RHD*
Alaska:	Adak	30	2.8	<0.10	1.3	Nov. 1963
	Anchorage	30	4.6	0.22	1.9	July 1963
	Attu	31	3.7	<0.10	1.2	Dec. 1963
	Fairbanks	14	3.4	<0.10	1.5	Aug. 1963
	Juneau	20	5.6	<0.10	2.2	Sep. 1963
	Kodiak	28	5.5	<0.10	1.4	Oct. 1963
	Nome	0	—	—	—	Feb. 1963
	Point Barrow	28	2.2	<0.10	<0.69	Mar. 1963
	St. Paul Island	28	5.1	<0.10	1.2	Apr. 1963
Ariz:	Phoenix	30	1.9	0.46	1.1	Sep. 1963
Ark:	Little Rock	25	7.4	0.62	4.5	Sep. 1963
Calif:	Berkeley	30	3.4	0.39	1.8	Oct. 1963
	Los Angeles	21	5.9	1.3	3.3	Feb. 1963
Colo:	Denver	30	5.2	0.55	1.8	Nov. 1963
Conn:	Hartford	29	7.1	0.50	3.4	Oct. 1963
Del:	Dover	20	10	0.27	4.9	Aug. 1963
D.C:	Washington	30	10	1.8	5.1	Mar. 1963
Fla:	Jacksonville	29	3.3	0.40	1.7	Oct. 1963
	Miami	29	3.9	0.56	1.5	Feb. 1963
Ga:	Atlanta	17	7.7	1.7	4.9	July 1963
Guam:	Agana	30	0.7	<0.10	<0.27	Mar. 1963
Hawaii:	Honolulu	30	3.3	0.14	1.6	Nov. 1963
Idaho:	Boise	29	18	1.75	5.2	Dec. 1963
Ill:	Springfield	29	6.8	1.2	3.7	Oct. 1962
Ind:	Indianapolis	31	7.8	0.48	4.1	July 1963
Iowa:	Iowa City	24	4.8	1.2	3.0	Nov. 1962
Kans:	Topeka	31	7.0	0.37	3.1	July 1963
Ky:	Frankfort	27	8.0	1.0	3.9	Mar. 1963
La:	New Orleans	30	5.4	0.93	2.1	Nov. 1962
Maine:	Augusta	31	10	0.17	3.8	Mar. 1963
	Presque Isle	30	7.9	0.48	3.2	Nov. 1963
Md:	Baltimore	23	8.8	<0.10	4.3	Nov. 1963
	Rockville	9	7.6	1.8	4.1	[b]
Mass:	Lawrence	29	11	0.93	4.8	Aug. 1963
	Winchester	28	7.6	0.56	3.7	[b]
Mich:	Lansing	31	8.5	1.3	4.0	Apr. 1963
Minn:	Minneapolis	30	7.2	1.8	4.0	Mar. 1963
Miss:	Jackson	27	7.8	1.4	4.0	Mar. 1963
	Pascagoula	2	4.6	3.7	4.3	Dec. 1963
Mo:	Jefferson City	29	5.8	0.30	3.2	Nov. 1963
Mont:	Helena	30	7.4	1.4	4.1	Nov. 1963
Nebr:	Lincoln	9	6.7	1.9	4.2	Apr. 1963
Nev:	Las Vegas	30	6.3	1.2	2.9	July 1963
N.H:	Concord	20	12	1.2	4.9	[b]
N.J:	Trenton	31	7.9	1.1	4.1	Oct. 1962
N. Mex:	Santa Fe	29	3.4	0.31	1.6	Dec. 1963
N.Y:	Albany	30	8.3	0.66	4.0	July 1963
	Buffalo	24	6.5	0.98	3.9	Nov. 1963
	New York	19	9.0	1.8	4.2	Dec. 1963
N.C:	Gastonia	31	8.2	1.2	4.4	Oct. 1962
N. Dak:	Bismarck	30	7.5	1.2	4.2	Feb. 1963
Ohio:	Cincinnati	22	6.3	0.73	3.5	Aug. 1963
	Columbus	30	7.3	1.43	4.0	Feb. 1963
	Painesville	30	8.9	1.8	5.0	Oct. 1963
Okla:	Oklahoma City	30	5.1	0.52	2.6	Apr. 1963
	Ponca City	30	3.8	0.20	1.8	Oct. 1963
Ore:	Portland	30	6.0	1.8	3.5	Oct. 1963
Pa:	Harrisburg	17	11	0.22	2.8	Dec. 1962
P.R:	San Juan	28	2.4	0.12	0.97	Apr. 1963
R.I:	Providence	31	8.8	0.85	4.1	Nov. 1962
S.C:	Columbia	30	5.9	0.56	3.0	Dec. 1963
S. Dak:	Pierre	31	6.1	0.67	3.0	Sep. 1963
Tenn:	Nashville	30	10	1.0	5.3	Feb. 1963
Tex:	Austin	29	4.5	0.53	1.8	Aug. 1963
	El Paso	30	2.2	0.45	1.1	Feb. 1963
Utah:	Salt Lake City	31	4.8	0.93	1.8	Aug. 1963
Vt:	Barre	30	9.6	0.44	3.9	Sep. 1963
Va:	Richmond	29	5.4	0.81	3.1	Sep. 1963
Wash:	Seattle	31	2.2	0.83	1.5	July 1963
W. Va:	Charleston	24	5.8	0.74	3.0	Dec. 1963
Wisc:	Madison	31	9.2	1.9	5.2	Sep. 1963
Wyo:	Cheyenne	28	5.2	0.61	2.0	Aug. 1963
Network summary		1,914	13	<0.10	3.1	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, AUGUST 1963

Station location		Average concentration (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	730	48
	Fairbanks	1,000	80
	Juneau	1,100	56
Ark:	Little Rock	490	44
Calif:	Berkeley	[b] —	[b] —
	Los Angeles	—	—
Colo:	Denver	1,100	53
Conn:	Hartford	1,400	48
D.C:	Washington	660	79
Fla:	Jacksonville	440	100
	Miami	410	58
Ga:	Atlanta	—	—
Idaho:	Boise	—	—
Ill:	Springfield	400	24
Ind:	Indianapolis	1,400	74
Iowa:	Iowa City	<400	< 7
Kans:	Topeka	960	27
Ky:	Frankfort	590	34
La:	New Orleans	570	98
Maine:	Augusta	1,300	120
	Presque Isle	700	130
Md:	Baltimore	810	40
Mass:	Lawrence	1,900	120
	Winchester	1,500	91
Mich:	Lansing	800	71
Minn:	Minneapolis	1,000	45
Miss:	Jackson	570	11
Mo:	Jefferson City	590	41
Mont:	Helena	3,100	39
Nebr:	Lincoln	1,800	24
Nev:	Las Vegas	—	—
N.J:	Trenton	1,200	12
N. Mex:	Santa Fe	620	28
N.Y:	Albany	820	38
	Buffalo	—	—
N.C:	Gastonia	410	25
N. Dak:	Bismarck	1,700	61
Ohio:	Columbus	820	98
	Painesville	930	48
Okla:	Oklahoma City	<400	< 7
	Ponca City	420	18
Ore:	Portland	460	9
Pa:	Harrisburg	1,000	47
P.R:	San Juan	410	36
R.I:	Providence	1,300	53
S.C:	Columbia	940	54
S. Dak:	Pierre	550	13
Tenn:	Nashville	640	83
Tex:	Austin	400	22
	El Paso	550	14
Utah:	Salt Lake City	740	15
Vt:	Barre	1,100	97
Va:	Richmond	1,200	29
Wash:	Seattle	1,200	21
W. Va.	Charleston	990	58
Wisc:	Madison	1,000	71
Wyo:	Cheyenne	1,100	47

[a] Depth of precipitation (mm) = $\frac{\text{deposition (nc/m}^2\text{ X 1000)}}{\text{concentration (pc/liter)}}$

[b] Dash indicates no evaporated sample received.

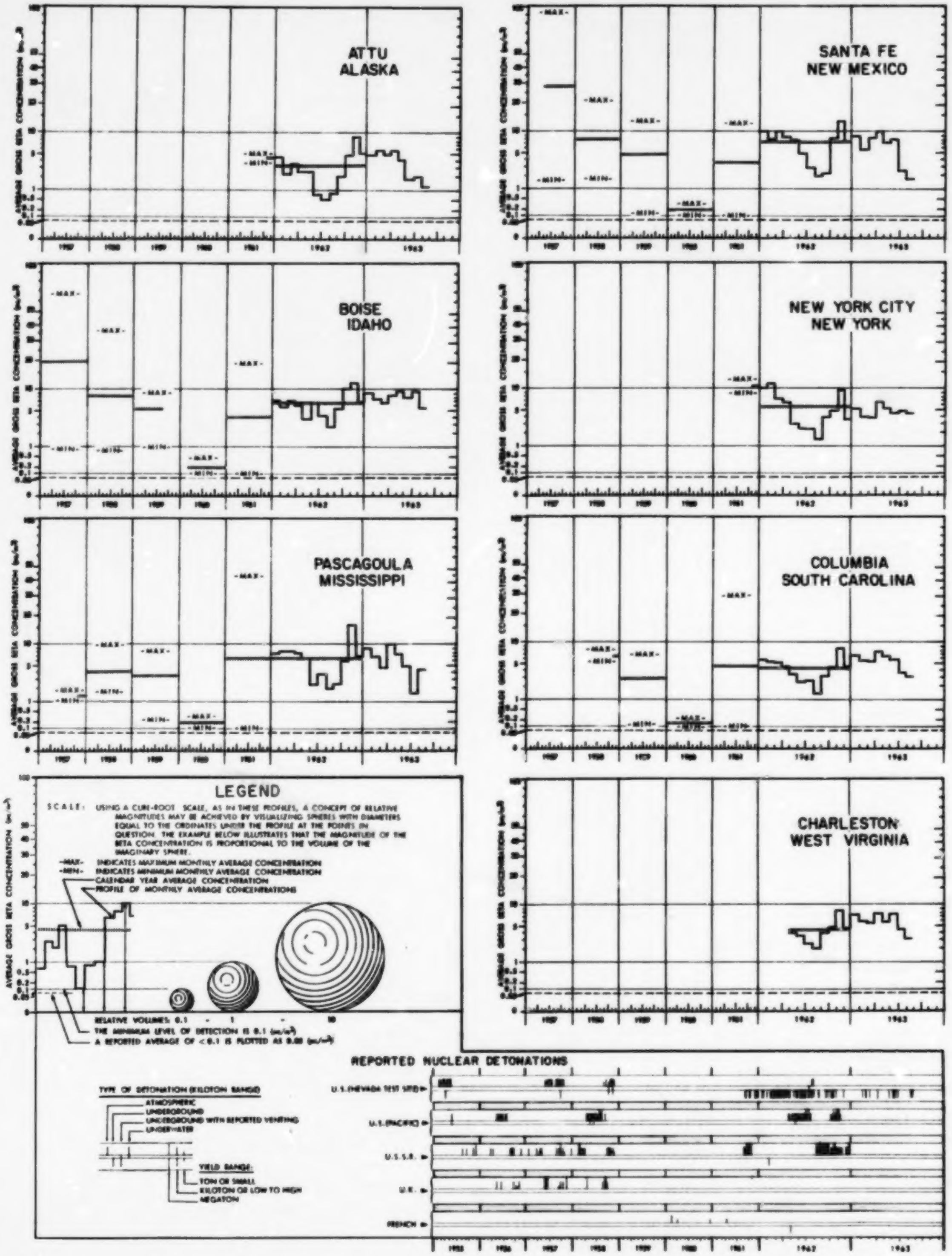


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957–AUGUST 1963

CANADIAN AIR MONITORING PROGRAM
August 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 3) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

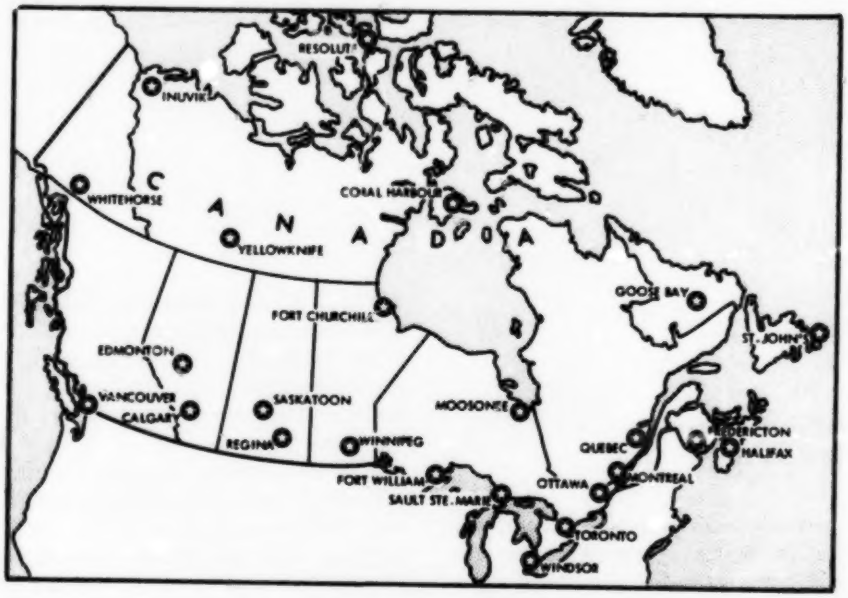
Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} stand-

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR—RFSP, AUGUST 1963

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	30	21.0	1.2	6.7
Coral Harbour	29	8.3	0.1	2.4
Edmonton	31	14.1	0.1	6.0
Ft. Churchill	27	7.9	0.1	2.7
Ft. William	31	11.7	1.9	5.7
Fredericton	31	9.1	0.4	4.5
Goose Bay	30	8.3	0.8	3.2
Halifax	31	12.3	0.2	4.5
Inuvik	31	9.2	0.5	3.5
Montreal	31	11.2	1.0	5.6
Moosonee	31	13.9	0.4	4.8
Ottawa	31	12.0	1.0	5.7
Quebec	31	12.8	0.7	5.1
Regina	31	13.7	2.5	7.0
Resolute	31	3.2	0.1	1.0
St. John's, Nfld	31	7.5	0.5	2.8
Saskatoon	27	16.0	2.1	7.1
Sault Ste. Marie	31	11.9	1.3	5.9
Toronto	28	10.5	0.8	4.7
Vancouver	29	5.0	1.8	3.3
Whitehorse	30	10.9	1.5	5.2
Windsor	30	11.0	0.6	6.3
Winnipeg	31	12.0	2.9	7.1
Yellowknife	31	10.2	0.3	4.2
Network summary	725	21.0	0.1	4.8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INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
REGINA
WINNIPEG
MOOSONEE
FREDERICTON
QUEBEC
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, AUGUST 1963

ard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for August 1963 are given in table 3 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 4).

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, AUGUST 1963

Station	Total beta activity	
	pc/liter	nc/m^2
Calgary	9,072	152.0
Coral Harbour	2,937	88.0
Edmondton	3,113	86.1
Ft. Churchill	3,351	40.0
Ft. William	1,683	155.9
Fredericton	1,633	224.2
Goose Bay	[a]	[a]
Halifax	1,138	180.8
Inuvik	2,470	52.0
Montreal	2,024	302.0
Moosonee	3,046	129.9
Ottawa	1,708	231.0
Quebec	1,241	211.4
Regina	2,660	135.7
Resolute	216	28.6
St. John's, Nfld	788	130.1
Saskatoon	4,084	178.3
Sault Ste. Marie	1,542	186.7
Toronto	678	43.5
Vancouver	4,800	69.4
Whitehorse	3,639	73.0
Windsor	1,693	71.3
Winnipeg	2,227	118.2
Yellowknife	2,979	122.5
Average	2,553	130.9

[a] No sample.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sampling container the polythene liner is removed, packed with the sample, and sent to the laboratory. Beta activities in precipitation for stations in Canada are presented in table 4.

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PAN AMERICAN AIR SAMPLING PROGRAM
August 1963

Pan American Health Organization
and Public Health Service

Gross beta activity in air is being monitored at three locations in South America under the auspices of a collaborative radiological health program between the Pan American Health Organization and the Public Health Service.

The three air sampling stations presently included in the program are located in Santiago, Chile; Lima, Peru; and Caracas, Venezuela. The Caracas station was activated in November 1962 and the other two stations entered in December of the same year.

The air sampling stations are manned by local personnel, and the sampling equipment and laboratory analyses are provided by the Public Health Service. Equipment and counting procedures are identical with those employed for the Radiation Surveillance Network. For intercalibration purposes, the two networks may, therefore, be regarded as one. Thus in figure 4, the Caracas station has been included with the Radiation Surveillance Network and the Canadian Air Network in the beta concentration isogram map. As with the Radiation Surveillance Network, an intercalibration factor of 1.54 was applied to the Caracas monthly average. Fission product gross beta activity data for August 1963 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY IN AIR, AUGUST 1963

[Concentrations in pc/m³]

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	22	1.73	<0.10	0.44
Lima Peru	14	0.17	<0.10	<0.13
Santiago, Chile	8	0.20	<0.10	<0.12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

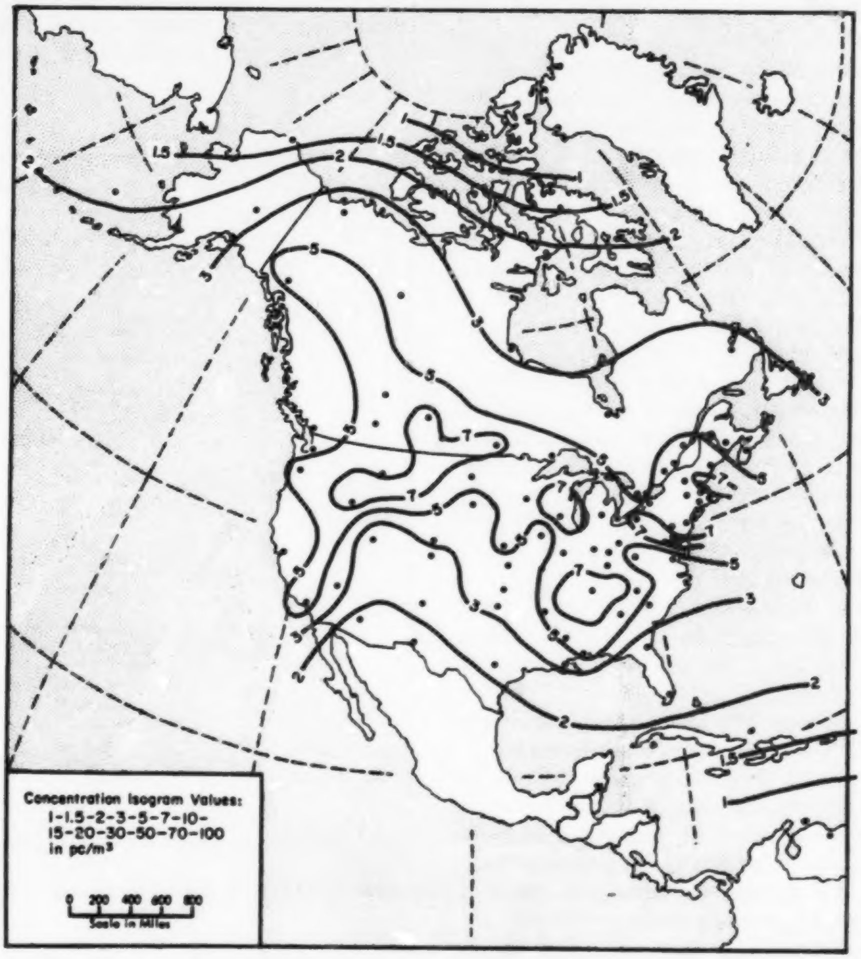
Concentration Isogram Values:
1-1.5-2-3-5-7-10-15-20-30-50-70-100 in pc/m³
0 200 400 600 800
Scale in Miles
1.5
2
3
5
7
1

FIGURE 4.—ISOGRAMS OF AIRBORNE GROSS BETA ACTIVITY FOR INTERCALIBRATED NETWORKS, AUGUST 1963

Fission Product Gamma Activity in Airborne Particulates

THE 80th MERIDIAN NETWORK
June and July 1963

William R. Collins Jr.[1]

Total gamma activity measurements for weekly ground-level air filter samples taken at the 80th Meridian stations (see figure 1) during June and July 1963 are listed in tables 1 and 2, respectively. Calculated ratios of gamma activity in excess of 1 Mev to total gamma activity are also listed in the tables. Average monthly total gamma activity concentrations calculated from the weekly values are plotted in figure 2 as an activity-latitude profile. For comparison, the profile of the second quarter 1963 averages is also included in figure 2. The gamma activity results for June and July show a general decrease in ground-level air concentrations in the Northern Hemisphere but little change or slight increase in the Southern Hemisphere with respect to second quarter averages. Maximum concentrations occurred, as usual, in both hemispheres in the mid-latitudes with minima in the equatorial and polar regions. The average value for June at the northern stations was 3.9 photons per minute per cubic meter (γ/min/m^3) with a range of from 1.4 to 5.8 γ/min/m^3. At the southern stations the average was 0.086 with a range of from 0.039 to 0.13 γ/min/m^3).

In July the average value for the Northern Hemisphere was 3.5 γ/min/m^3 with a range of from 1.08 to 5.7 γ/min/m^3. At the Southern Hemisphere stations the average concentration was 0.101 with a range of from 0.030 to 0.21.

Total beta activity estimates, which are usually given in these reports, are not given for the June or July samples because of the detection of significant concentrations of activation products with high energy to total gamma activity ratios and theoretical beta to gamma activity ratios that are appreciably different from those of mixed fission products. Since debris from even the latest of the 1962 nuclear tests would have been more than 150 days old by the end of May 1963, only about 1 percent of the total gamma activity in the June 1963 samples would be expected to be of energies higher than 1 Mev, and the total beta activity of the samples would be expected to be about three times the total gamma activity. The actual high-energy gamma to total gamma activity ratios in June range from 0.024 to 0.18 with averages of 0.051 and 0.074 for the Northern and Southern hemispheres, respectively. The most prominent high energy component of the sample spectra appears to be Sb^{124}, which has a theoretical beta-to-gamma activity ratio of 1.0.

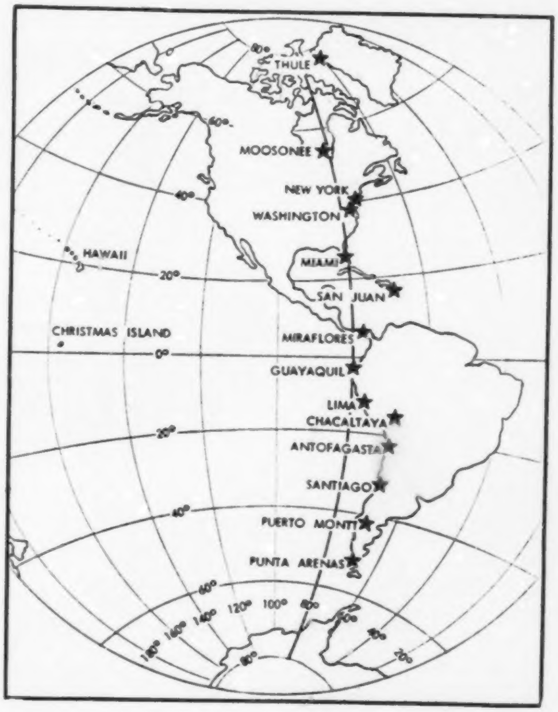

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

If it is assumed that the disparity between the actual and expected high energy to total gamma activity ratios is caused by Sb^{124} alone, it is estimated that during June about 14 percent of the average monthly total gamma activity concentration in the Northern Hemisphere and 27 percent of the average in the Southern Hemisphere were due to Sb^{124} activity. These estimates might be used to obtain estimates of total fission product beta activity, but no valid conversion from total gamma activity to total beta activity is possible without further knowledge of the individual activation product concentrations. In a similar way, it was

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TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, JUNE 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m^3) Filter	Gamma activity (photons/min/m^3) Average for month	Gamma ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$
Thule	1–8	1.70		0.054
	8–15	2.88		0.055
	15–22	1.84		0.054
	22–7/1	2.29	2.18	0.052
Moosonee	1–8	4.56		0.052
	8–15	4.72		0.051
	15–22	5.41		0.054
	22–7/1	8.64	5.83	0.052
New York	1–8	3.72		0.058
	8–15	3.62		0.057
	15–22	8.01		0.060
	22–7/1	5.09	5.11	0.057
Washington	1–8	3.16		0.051
	8–15	6.27		0.054
	15–22	8.76		0.053
	22–7/1	9.09	6.82	0.053
Miami	1–8	2.50		0.039
	8–15	2.50		0.050
	15–22	3.46		0.051
	22–7/1	3.44	2.98	0.050
Mauna Loa	1–8	3.57		0.052
	8–15	3.36		0.053
	15–22	3.77		0.051
	22–7/1	3.81	3.63	0.051
San Juan	1–8	2.65		0.053
	8–15	4.75		0.051
	15–22	2.63		0.050
	22–7/1	2.84	3.22	0.051
Miraflores	1–8	1.96		0.053
	8–15	0.0389		0.024
	15–22	0.866		0.051
	22–7/1	2.54	1.35	0.047
Guayaquil	1–8	0.0510		0.090
	8–15	0.0847		0.082
	15–22	0.0599		0.096
	22–7/1	0.0719	0.0669	0.108
Lima	1–8	0.0777		0.051
	8–15	0.101		0.056
	15–22	0.0778		0.076
	22–7/1	0.128	0.0961	0.078
Chacaltaya	1–8	0.0587		0.052
	8–15	0.0959		0.051
	15–22	0.135		0.057
	22–7/1	0.238	0.132	0.054
Antofagasta	1–8	0.104		0.065
	8–15	0.0950		0.048
	15–22	0.135		0.053
	22–7/1	0.135	0.117	0.053
Santiago	1–8	0.0783		0.111
	8–15	0.0849		0.110
	15–22	0.152		0.076
	22–7/1	0.0804	0.0989	0.107
Puerto Montt	1–8	0.0499		0.088
	8–15	0.0376		0.105
	15–22	0.0638		0.090
	22–7/1	0.0473	0.0497	0.122
Punta Arenas	1–8	0.0494		0.104
	8–15	0.0169		0.176
	15–22	0.0425		0.084
	22–7/1	0.0479	0.0392	0.127

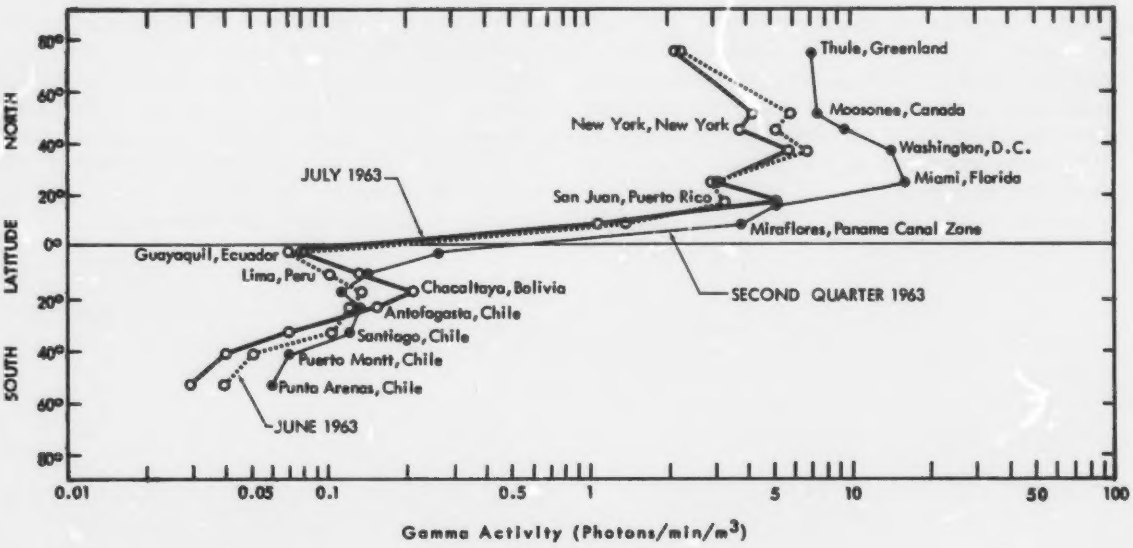

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, SECOND QUARTER, JUNE AND JULY, 1963

TABLE 2.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, JULY 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\left(\frac{\gamma > 1\ \text{Mev}}{\text{total}\ \gamma}\right)$
		Filter	Average for month	
Thule	1-8	1.09		0.039
	8-15	3.05		0.041
	15-22	1.98		0.034
	22-8/1	1.88	2.00	0.032
Moosonee	1-8	3.64		0.034
	8-15	5.51		0.040
	15-22	3.19		0.038
	22-8/1	4.75	4.23	0.032
New York	1-8	4.69		0.042
	8-15	1.09		0.042
	15-22	3.16		0.040
	22-8/1	3.92	3.72	0.042
Washington	1-8	6.90		0.033
	8-15	6.26		0.040
	15-22	5.19		0.033
	22-8/1	4.51	5.72	0.039
Miami	1-8	2.05		0.032
	8-15	2.42		0.039
	15-22	3.82		0.039
	22-8/1	3.91	3.05	0.039
Mauna Loa	1-8	4.39		0.041
	8-15	4.75		0.040
	15-22	2.47		0.039
	22-8/1	0.971	3.15	0.040
San Juan	1-8	2.50		0.036
	8-15	2.82		0.037
	15-22	5.29		0.039
	22-8/1	2.83	5.04	0.040
Miraflores	1-8	0.376		0.028
	8-15	0.894		0.040
	15-22	0.484		0.039
	22-8/1	1.13	1.08	0.040
Guayaquil	1-8	0.0967		0.037
	8-15	0.0447		0.044
	15-22	0.0893		0.022
	22-8/1	0.0760	0.0767	0.046
Lima	1-8	0.112		0.032
	8-15	0.0978		0.038
	15-22	0.123		0.036
	22-8/1	0.186	0.130	0.040
Chacaltaya	1-8	0.162		0.038
	8-15	0.204		0.042
	15-22	0.105		0.043
	22-8/1	0.365	0.209	0.043
Antofagasta	1-8	0.160		0.033
	8-15	0.117		0.026
	15-22	0.108		0.043
	22-8/1	0.219	0.151	0.049
Santiago	1-8	0.0546		0.015
	8-15	0.0275		0.066
	15-22	0.133		0.047
	22-8/1	0.0629	0.0695	0.045
Puerto Montt	1-8	0.0431		0.047
	8-15	0.0506		0.025
	15-22	0.0363		0.020
	22-8/1	0.0302	0.0401	0.047
Punta Arenas	1-8	0.0233		0.041
	8-15	0.0538		0.038
	15-22	0.0230		0.024
	22-8/1	0.0185	0.0297	0.086

estimated that an average of about 10 percent of July activity concentrations in both hemispheres resulted from activation products.

An indication of the accuracy of the total activation product activity approximations is given by the results of gamma ray spectrometric analyses of April and May 80th Meridian samples. Since no photopeaks of higher energy than the Sb^{124} peaks appeared in the sample spectra for these two months, Sb^{124} could be determined by a relatively simple stripping technique. For April the results averaged 0.36 d/min/m^3 or 3.0 percent of the total gamma activity and 0.021 d/min/m^3 or 10 percent of the total gamma activity for the Northern and Southern Hemispheres, respectively. For May the results averaged 0.26 d/min/m^3 or 4.1 percent and 0.0067 d/min/m^3 or 7.3 percent of the Northern and Southern Hemispheres respectively. These values agree with those calculated from the difference in expected and actual high-energy gamma to total gamma activity ratios to better than 20 percent.

SECTION II.—MILK AND FOOD

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
August 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. More milk sampling points continued to be added until July 1962, when the total number of stations reached 62.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, or Northeastern Radiological Health Laboratories for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to the States for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

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Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as the measured concentration at which the statistical two-standard-deviation analytical error is 100 percent (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 1 presents summaries of the analyses for August 1963 (July 28–August 31, 1963). When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used in calculating the monthly average. A similar procedure is used for the network average.

Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.3 to 1.8 grams/liter. In August, for example, 1, 13, 20, 20, 7, and 1 stations had monthly average potassium concentrations respectively as follows: 1.3, 1.4, 1.5, 1.6, 1.7, and 1.8 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated strontium-89 and strontium-90 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. In order to show the distribution of the network's stations versus radionculide concentrations in milk, table 2 has been prepared using monthly average data shown in table 1.

Figure 3 shows by means of isoconcentration maps the estimated cesium-137 concentration in milk in the United States since the third quarter of 1961. The value printed beside each station is the average concentration for that station for the time period covered by the map.

The third quarter cesium-137 average concentrations in milk at all stations was less than 25 pc/liter, except at four stations in the Northeast and three stations in the Southeast. The highest average was 85 pc/liter during this period. This same pattern of cesium-137 concentrations is apparent in the fourth quarter of 1961. All stations except two reported fourth quarter averages of 25 pc/liter or less. Pascagoula, Mississippi reported 30 pc/liter and Tampa, Florida reported 70 pc/liter.

The trend observed for cesium-137 in the last half of 1961 continued in the first quarter 1962. Four stations in the Southeast had first quarter 1962 averages of 30 to 70 pc/liter; all other stations had lesser concentrations. Cesium-137 in the environment increased during the second quarter of 1962 as reflected in the increase in the cesium-137 second quarter 1962 average concentrations in milk over the first quarter 1962 values at nearly all stations. The Southwest had concentrations of 15 pc/liter or less while the Southeastern States had concentrations of 50 to 135 pc/liter. Nearly all other stations reported cesium-137 second quarter average concentrations intermediate to these ranges. The third quarter 1962 and fourth quarter 1962 isoconcentration maps appear similar and are discussed together. The change occurring from the second quarter 1962 to the last two quarters of 1962 in the quarterly cesium-137 concentrations in milk was as follows: concentrations in the Southwest increased slightly from the teens into the twenties; concentrations in the other Southern States previously between 50 and 100 pc/liter changed to 40 to 70 pc/liter; concentrations in the northern half of the United States, previously between 20 and 50 pc/liter, rose to the seventies and eighties, except in the New England States, where values in the 100 to 145 pc/liter range were recorded; concentrations in Florida remained greater than 100 pc/liter, but less than 145 pc/liter.

As shown by the first quarter 1963 cesium-137 averages, the entire country except the Southwest reflected concentrations in milk of between 50 and 135 pc/liter. As was the usual pattern, the southwestern stations reported values below the rest of the nation. From the second quarter 1963 cesium–137 averages, it was apparent that levels were still increasing. A majority of stations reported values between 80 and 140 pc/liter. Concentrations below 50 pc/liter were observed in the Southwest only. The maximum second quarter average (200 pc/liter) was observed at the Florida station.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

Cesium–137 average concentrations for July 1963 ranged from 15 to 50 pc/liter, while the South-

Table 1.—RADIOACTIVITY IN PASTEURIZED MILK, AUGUST 1963 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Strontium–89		Strontium–90		Cesium–137		Barium–140		Last Profile in *RHD*
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Month (1968)
Ala:	Montgomery	1.21	1.17	100	50	23	22	80	90	10	<10	Oct.
Alaska:	Palmer	1.17	1.19	35	50	15	27	55	200	<10	<10	Nov.
Ariz:	Phoenix	1.16	1.17	20	5	5	3	15	25	<10	<10	Sep.
Ark:	Little Rock	1.19	1.20	200	125	51	47	195	190	20	<10	Nov.
Calif:	Sacramento	1.21	1.20	115	10	19	6	90	45	<10	<10	Dec.
	San Francisco	1.22	1.17	175	15	27	9	110	60	<10	<10	Oct.
Colo:	Denver	1.23	1.24	35	25	14	21	70	105	<10	<10	Dec.
Conn:	Hartford	1.09	1.16	30	45	22	32	120	225	<10	<10	Dec.
Del:	Wilmington	1.07	1.18	65	40	28	28	130	155	<10	<10	Sep.
D.C:	Washington	1.16	1.13	90	40	24	20	120	105	<10	<10	Oct.
Fla:	Tampa	1.18	1.20	40	30	13	15	200	275	10	<10	Sep.
Ga:	Atlanta	1.21	1.16	145	75	33	33	155	175	10	<10	Oct.
Hawaii:	Honolulu	1.15	1.17	60	10	10	11	65	80	<10	<10	Nov.
Idaho:	Idaho Falls	1.20	1.16	80	40	22	30	110	145	<10	<10	Sep.
Ill:	Chicago	1.06	1.20	30	20	21	26	95	110	<10	<10	Oct.
Ind:	Indianapolis	1.10	1.20	55	45	29	23	100	125	<10	<10	Dec.
Iowa:	Des Moines	1.19	1.19	145	35	31	27	95	80	<10	<10	Sep.
Kans:	Wichita	1.19	1.15	90	25	21	20	85	65	<10	<10	Nov.
Ky:	Louisville	1.18	1.13	180	100	37	40	125	140	10	<10	Sep.
La:	New Orleans	1.23	1.21	175	70	45	43	170	165	20	<10	Nov.
Maine:	Portland	1.07	1.15	30	65	2[illegible]	37	120	320	<10	<10	Sep.
Md:	Baltimore	1.15	1.15	105	55	2[illegible]	26	140	150	10	<10	Sep.
Mass:	Boston	1.10	1.17	35	75	28	46	150	380	<10	<10	Oct.
Mich:	Detroit	1.08	1.19	25	35	20	19	85	140	<10	<10	Dec.
	Grand Rapids	1.11	1.17	25	35	19	22	90	145	<10	<10	Sep.
Minn:	Minneapolis	1.20	1.19	80	55	28	35	130	165	<10	<10	Oct.
Miss:	Jackson	1.25	1.22	180	80	38	37	120	135	20	<10	Dec.
Mo:	Kansas City	1.21	1.15	155	35	32	27	100	75	<10	<10	Dec.
	St. Louis	1.19	1.12	110	25	27	24	95	85	<10	<10	Nov.
Mont:	Helena	1.19	1.15	70	70	21	44	105	255	<10	<10	Nov.
Nebr:	Omaha	1.21	1.16	100	35	27	28	90	85	<10	<10	Sep.
Nev:	Las Vegas	1.15	1.18	25	15	7	9	50	75	<10	<10	Oct.
N.H:	Manchester	1.12	1.15	40	65	28	41	170	375	<10	<10	Sep.
N.J:	Trenton	1.09	1.19	40	35	26	25	110	155	<10	<10	Dec.
N. Mex:	Albuquerque	1.16	1.17	40	20	10	11	35	50	<10	<10	Nov.
N.Y:	Buffalo	1.06	1.14	30	40	22	26	105	175	<10	<10	Dec.
	New York	1.09	1.15	40	60	24	42	110	265	<10	<10	Oct.
	Syracuse	1.08	1.16	35	40	24	30	105	170	<10	<10	Nov.
N.C:	Charlotte	1.25	1.17	135	75	34	36	130	155	10	<10	Nov.
N. Dak:	Minot	1.13	1.17	180	95	48	58	115	260	<10	<10	Sep.
Ohio:	Cincinnati	1.09	1.22	75	40	31	30	90	100	<10	<10	Dec.
	Cleveland	1.13	1.16	40	35	24	23	100	140	<10	<10	Nov.
Okla:	Oklahoma City	1.17	1.13	130	45	28	22	120	85	10	<10	Oct.
Ore:	Portland	1.24	1.21	165	30	38	32	160	180	<10	<10	Dec.
Pa:	Philadelphia	1.08	1.10	55	30	29	25	130	145	<10	<10	Nov.
	Pittsburgh	1.10	1.22	55	55	27	40	125	210	<10	<10	Nov.
P.R:	San Juan	1.16	1.16	105	35	18	15	125	100	10	<10	Nov.
R.I:	Providence	1.08	1.19	45	45	27	33	125	235	<10	<10	Sep.
S.C:	Charleston	1.21	1.16	100	60	29	26	120	150	10	<10	Dec.
S. Dak:	Rapid City	0.92	1.06	105	80	34	45	125	170	<10	<10	Oct.
Tenn:	Chattanooga	1.22	1.21	195	110	40	51	160	180	10	<10	Oct.
	Memphis	1.22	1.17	160	70	38	35	110	90	10	<10	Sep.
Tex:	Austin	1.14	1.12	50	15	10	8	50	40	<10	<10	Oct.
	Dallas	1.16	1.15	120	40	25	20	100	80	10	<10	Dec.
Utah:	Salt Lake City	1.22	1.18	45	40	20	25	110	180	<10	<10	Nov.
Vt:	Burlington	1.09	1.16	30	60	24	41	110	270	<10	<10	Dec.
Va:	Norfolk	1.17	1.14	95	40	25	24	120	110	10	<10	Dec.
Wash:	Seattle	1.19	1.21	125	40	26	33	150	195	<10	<10	Oct.
	Spokane	1.26	1.25	105	40	27	27	125	155	<10	<10	Dec.
W. Va:	Charleston	1.17	1.12	145	85	37	36	115	125	10	<10	Oct.
Wis:	Milwaukee	1.10	1.21	30	35	20	21	90	140	<10	<10	Sep.
Wyo:	Laramie	1.20	1.14	70	30	24	22	120	115	<10	<10	Sep.
Network average		1.16	1.17	87	47	25.9	28.1	112	150	<10	<10	Nov.

[a] The monthly average iodine–131 concentration at each station was <10 pc/liter.

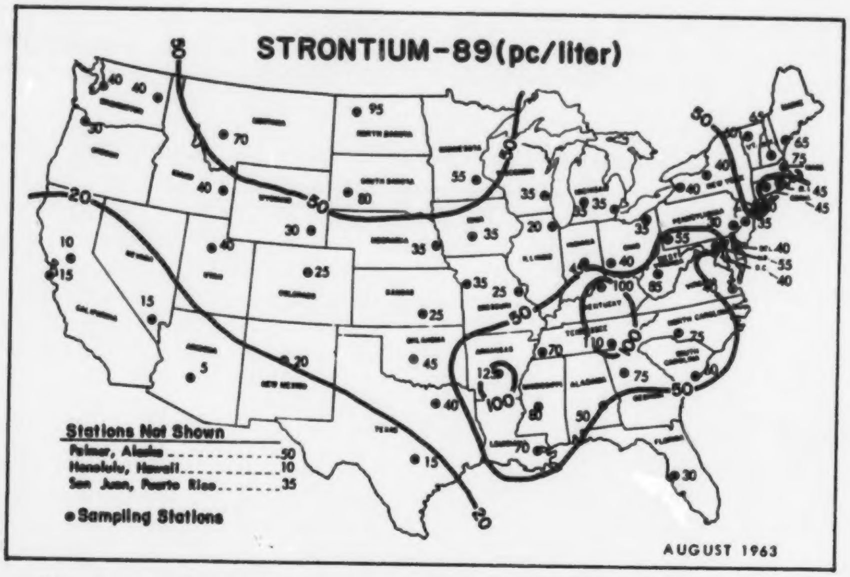
STRONTIUM-89 (pc/liter)
Stations Not Shown
Palmer, Alaska 50
Honolulu, Hawaii 10
San Juan, Puerto Rico 35
● Sampling Stations
AUGUST 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

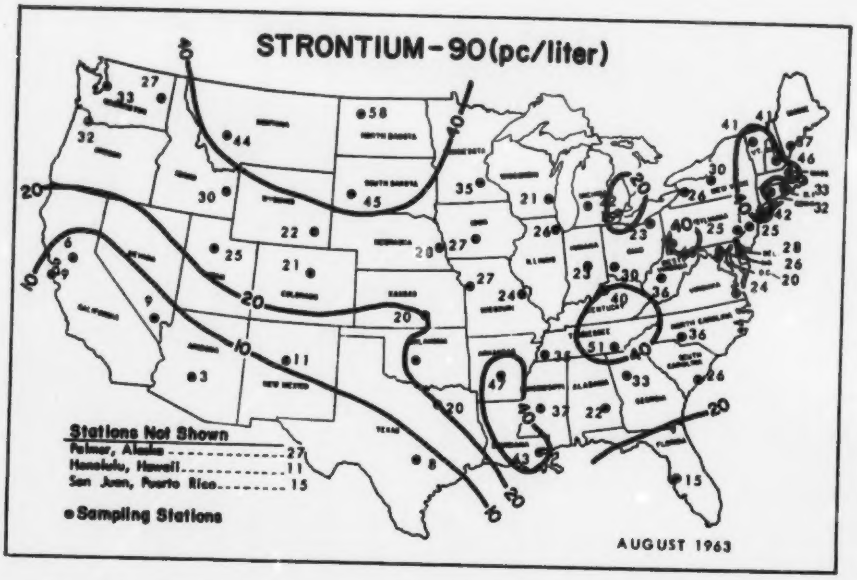
STRONTIUM-90 (pc/liter)
Stations Not Shown
Palmer, Alaska 27
Honolulu, Hawaii 11
San Juan, Puerto Rico 15
● Sampling Stations
AUGUST 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

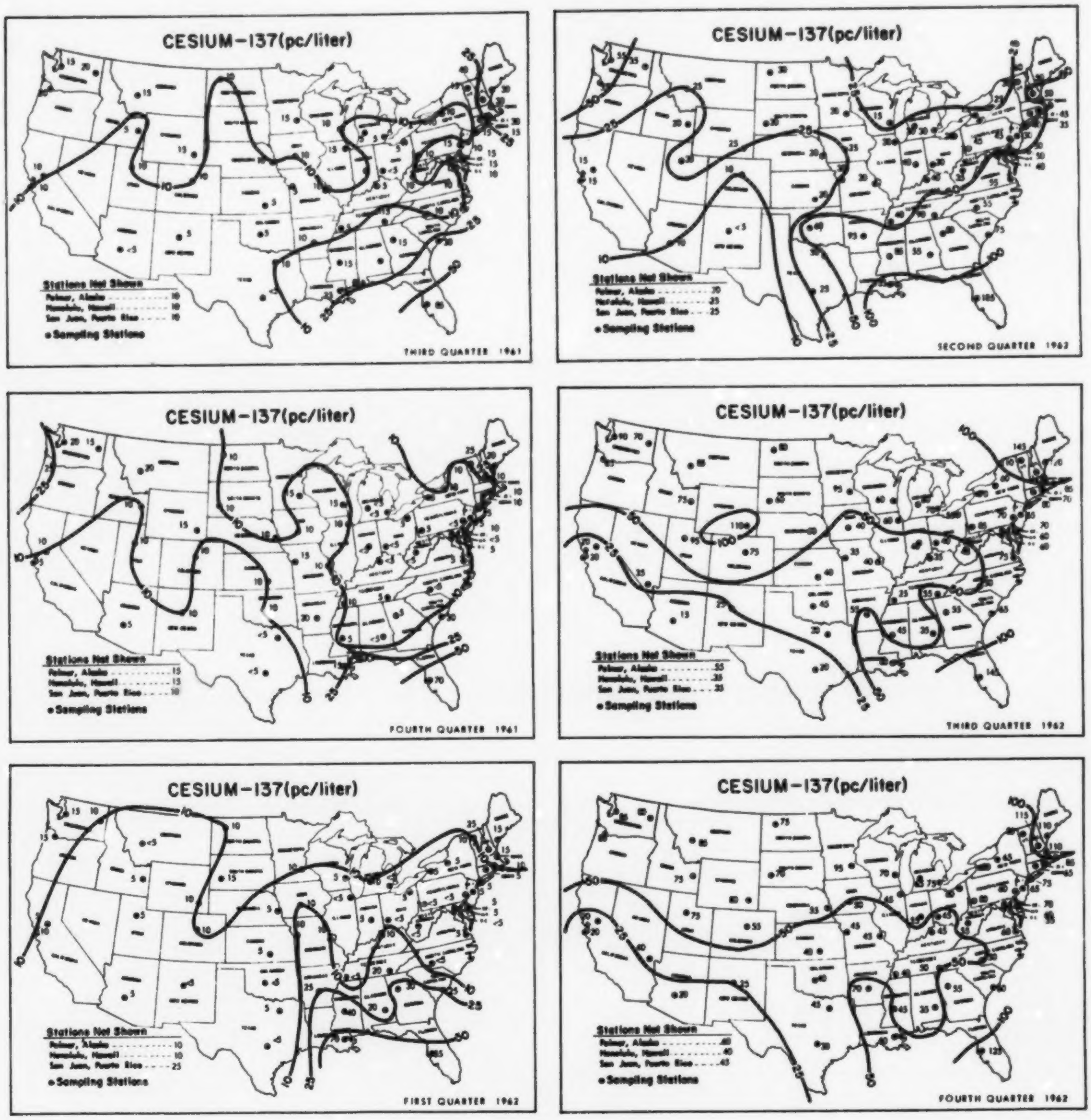
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 10
San Juan, Puerto Rico 10
• Sampling Stations
THIRD QUARTER 1961
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 20
Honolulu, Hawaii 25
San Juan, Puerto Rico 25
• Sampling Stations
SECOND QUARTER 1962
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii 15
San Juan, Puerto Rico 10
• Sampling Stations
FOURTH QUARTER 1961
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 35
Honolulu, Hawaii 35
San Juan, Puerto Rico 35
• Sampling Stations
THIRD QUARTER 1962
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 10
San Juan, Puerto Rico 25
• Sampling Stations
FIRST QUARTER 1962
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 40
Honolulu, Hawaii 40
San Juan, Puerto Rico 45
• Sampling Stations
FOURTH QUARTER 1962

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

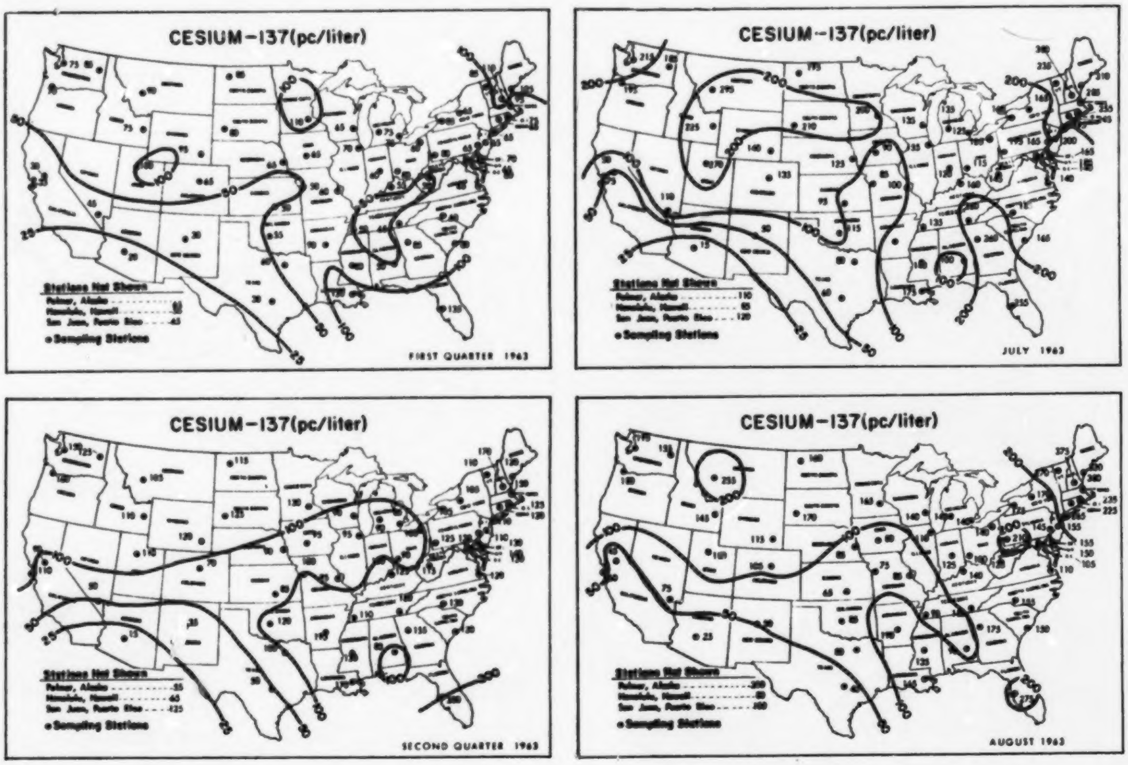
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Sampling Stations
FIRST QUARTER 1963
JULY 1963
SECOND QUARTER 1963
AUGUST 1963

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK-Continued

TABLE 2.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONCULIDE CONCENTRATIONS IN MILK, AUGUST 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5-20	8	<1-9	5	<10	62	<5-45	3	<10	62
25-45	31	10-19	5			50-95	13		
50-70	13	20-29	26			100-145	17		
75-95	7	30-39	14			150-195	18		
100-120	2	40-49	10			200-245	4		
125-145	1	50-59	2			250-295	4		
						300-345	1		
						350-400	2		

western States averaged 50 pc/liter or less. The New England States reported the highest levels (200 to 380 pc/liter). Other areas with averages of 200 to 300 pc/liter in July 1963 are western Washington, a region extending westward from Minnesota to Idaho, and a section extending through Florida and Georgia northward into Tennessee.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of *Radiological Health Data,* the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented (see figure 4). Each graph shows the strontium-90 concentrations in milk

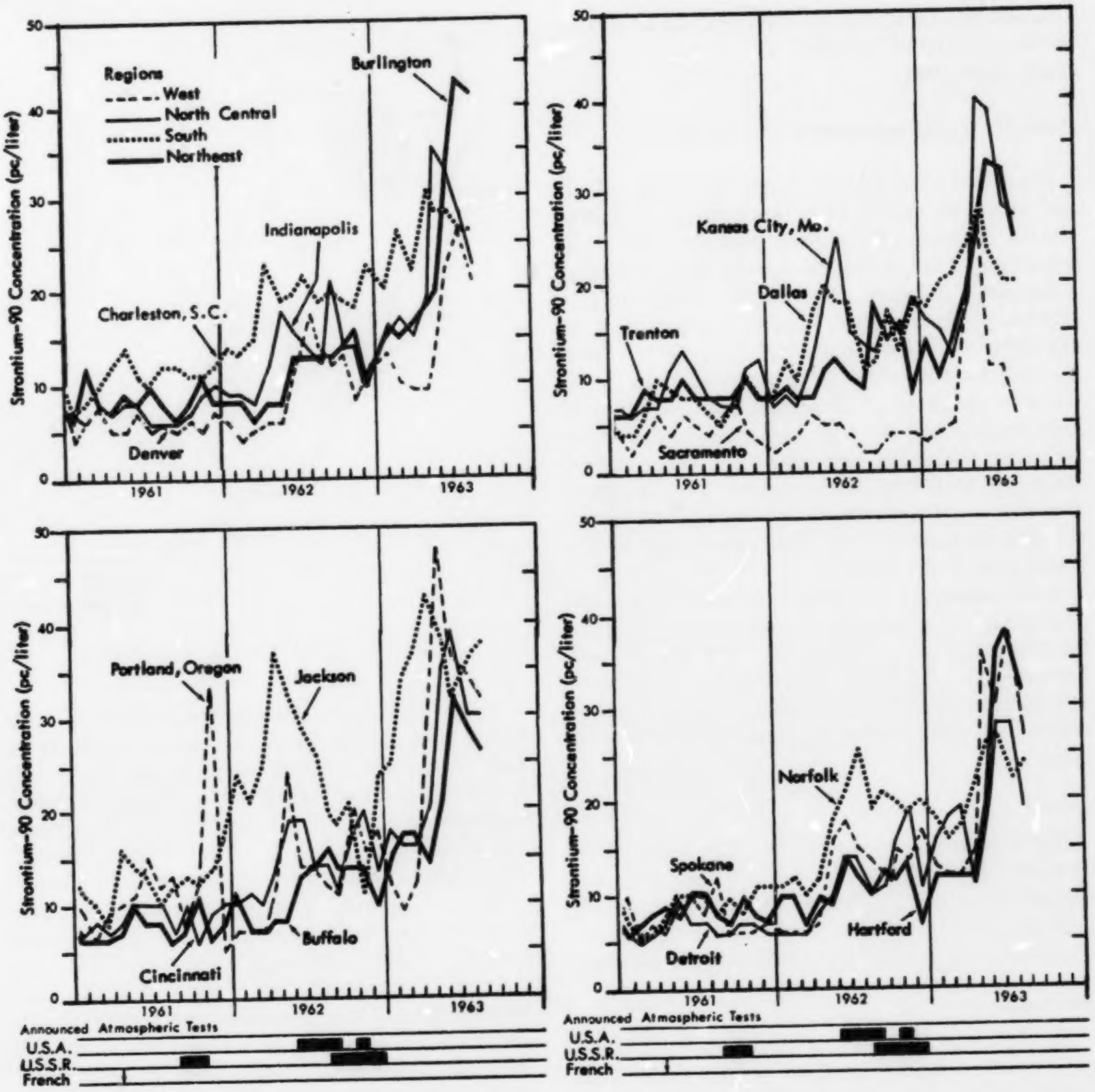

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network at least twice a year.

REFERENCE

(1) Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291–6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

CALIFORNIA MILK NETWORK AND MILKSHED COMPARISONS
April–June 1963

John M. Heslep and Amasa C. Cornish [1]

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, sampling of milk weekly or biweekly, has been conducted at 10 major milksheds (see figure 5). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Radiostrontium is separated chemically and counted in a low background counter, usually for a 60-minute period. Iodine–131, cesium–137, and barium–140 in fluid milk are determined by gamma scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used.

Results

The monthly averages of the radionuclide data in milk for the period April–June 1963 are presented in table 3. When the result from an individual analysis was reported as not significant, a value of zero was used in calculating the average.

Discussion

As shown in table 3 and previously published data (*1–3*), fission product concentrations in California milk were low until 1961. The November 1961 average Sr^{89} concentrations in Humboldt milk increased sharply from the previous monthly average to 160 pc/liter. This increase was accompanied by only a negligible increase in Sr^{90}. In December 1961, Humboldt milk averaged 314 and 12 pc/liter of Sr^{89} and Sr^{90}, respectively. During this period Del Norte milk was not yet being sampled. No appreciable increases were noted from other areas.

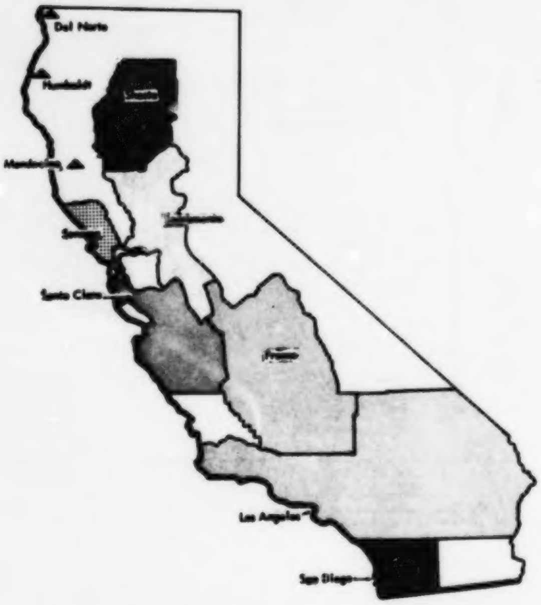

FIGURE 5.—CALIFORNIA MILKSHEDS

In considering the radiostrontium data in table 3 on a comparative basis, 3 classes of values from high to low can be observed: (1) Del Norte; (2) Humboldt; and (3) Mendocino, Shasta, Sonoma, Sacramento, Santa Clara, Los Angeles, San Diego, and Fresno (see figure 6). The location, rainfall, and average annual Sr^{90} at each station are given in table 4. Generally, milk radiostrontium tends to decrease from north to south and with decreasing rainfall. There are anomalies, however. For example, Humboldt has less rainfall than Mendocino and has about the same rainfall and is about the same latitude as Shasta. Yet Humboldt milk contained about twice as much radiostrontium as that from either Mendocino or Shasta. Also, there is no obvious explanation related to rainfall or geographical location which can account for the large difference which exists between Del Norte milk and that from any other location in the State.

Although Del Norte milk contains the highest radioactive analysis of any milkshed in California, it represents only 0.12 percent of the State's market milk (Grade A) and 0.34 percent of the manufacturing milk. The 1962 total milk production for Del Norte was 13,644,000 pounds. Seventy percent of the Grade A milk (market milk) produced in Del Norte is marketed in the County.

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TABLE 3.—RADIONUCLIDES IN CALIFORNIA MILK, APRIL–JUNE 1963

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
April	1.28	1.21	1.25	1.10	1.18	1.18	1.13	1.17	1.14	1.20	1.18
May	1.32	1.21	1.24	1.08	1.21	1.15	1.14	1.14	1.16	1.18	1.18
June	1.32	1.17	1.23	1.07	1.15	1.13	1.15	1.12	1.13	1.18	1.17
Potassium-40											
April	1160	1230	1200	1250	1260	1230	1240	1250	1190	1190	1220
May	1210	1230	1200	1270	1280	1200	1200	1260	1220	1220	1229
June	1180	1260	1210	1280	1290	1240	1270	1240	1220	1230	1242
Strontium-89											
April	1323	30	493	8	199	99	16	35	154	241	260
May	941	56	365	18	230	109	27	54	147	188	214
June	269	31	63	18	68	45	11	33	69	65	62
Strontium-90											
April	184	6.6	71	4.0	27	14	4.3	7.3	23	33	37
May	148	10.1	52	4.8	33	17	5.8	11	22	29	23
June	77	8.2	17	4.4	15	10	3.5	7.7	17	17	18
Iodine-131											
April	[a] 0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	2	0	0	0	3	0	1
June	0	0	0	0	0	1	0	0	0	0	0
Cesium-137											
April	528	53	198	22	102	88	26	37	124	162	134
May	485	77	176	37	126	110	43	85	125	140	140
June	295	90	65	50	71	83	37	86	112	92	98
Barium-140											
April	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0

[a] A zero indicates no significant activity.

TABLE 4.—COMPARISON OF RAINFALL DATA WITH STRONTIUM-90 CONCENTRATIONS IN MILK FOR CALIFORNIA MILKSHEDS, AUGUST 1962–JULY 1963

Milkshed	Rainfall collection locations		Mean annual rainfall (inches)	Rainfall Aug 1962–July 1963 (inches)	Average Sr^{90} concentrations Aug 62–July 63 (pc/liter)
	Latitude	Longitude			
Del Norte	41°46′	124°12′	79	72	69
Mendocino	39°22′	123°08′	44	49	11
Shasta	40°34′	122°23′	38	41	10
Humboldt	40°48′	124°10′	36	44	25
Sonoma	38°27′	122°42′	29	36	11
Sacramento	38°31′	121°30′	16	25	7
Santa Clara	37°21′	121°56′	15	22	5
Los Angeles	33°56′	118°23′	15	10	3
San Diego	32°44′	117°10′	11	4	3
Fresno	36°46′	119°43′	9	12	5

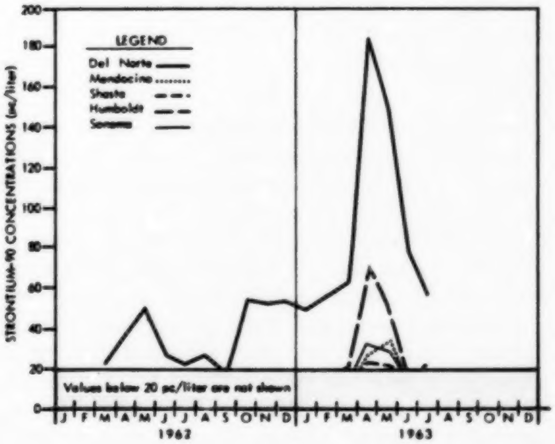

FIGURE 6.—MONTHLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN MILK FROM ALL CALIFORNIA MILKSHEDS

The remaining 30 percent is shipped to Oregon. Del Norte manufacturing milk, which is used for making cheese, is about equally divided with Oregon.

Since there is a relatively long delay in obtaining results of Sr^{90} analyses, an attempt to estimate the concentrations of Sr^{90} in milk based on Cs^{137} concentrations may be made. In order to make this estimate, an empirically determined average Cs^{137}/Sr^{90} ratio for a particular milkshed must be derived. If the Cs^{137} content of milk (which may be determined quickly) from a particular milkshed is known, then by dividing this value by the average Cs^{137}/Sr^{90} ratio for this milkshed, an estimate of the Sr^{90} content of the milk is available.

Table 5 indicates the Cs^{137}/Sr^{90} ratios by location and month, where Sr^{90} values were 10 pc/liter or more. These ratios are formed by dividing the monthly average Cs^{137} content of milk by the

TABLE 5.—RATIOS OF CESIUM-137 TO STRONTIUM-90 FOR CALIFORNIA MILKSHEDS,[a] JANUARY 1962–JULY 1963

Month		Milkshed									
		Del Norte	Mendocino	Shasta	Humboldt	Sonoma	Sacramento	Santa Clara	Los Angeles	San Diego	Fresno
1962	Jan.										
	Feb.				6.5						
	Mar.	5.4			4.6						
	Apr.	2.8			7.7						
	May	3.4			5.0						
	June	3.3									
	July	2.6									
	Aug.	3.6									
	Sept.	3.3									
	Oct.	3.2			4.7						
	Nov.	3.0			5.0						
	Dec.	3.1			3.4						
1963	Jan.	2.1			2.4						
	Feb.	3.3			4.3						
	Mar.	3.8	4.8		4.0	4.4					
	Apr.	2.9	3.8	5.4	2.8	4.9	6.3				
	May	3.2	3.8	5.8	3.4	4.8	6.4	7.7			7.7
	June	3.8	4.6	6.6	3.9	5.4	8.3				
	July	3.1		5.4	4.4	6.4					
Average		3.3	4.2	5.8	4.4	5.2	7.0	7.7	—	—	7.7

[a] Ratios are given when strontium-90 concentrations were 10 pc/liter or more.

TABLE 6.—RATIOS OF STRONTIUM-89 TO STRONTIUM-90 FOR CALIFORNIA MILKSHEDS,[a] JANUARY 1962–JULY 1963

Month		Milkshed								
		Del Norte	Mendocino	Shasta	Humboldt	Sonoma	Sacramento	Los Angeles	San Diego	Fresno
1962	Jan.									
	Feb.				19.6					
	Mar.	16.2			17.4					
	Apr.	12.0			13.3					
	May	8.6			10.0					
	June	5.0								
	July	3.6								
	Aug.	3.5								
	Sept.	3.6								
	Oct.	10.8			12.1					
	Nov.	11.4			18.8					
	Dec.	18.9			17.7					
1963	Jan.	11.9			13.7					
	Feb.	12.6			14.2					
	Mar.	12.5	12.2		12.5	11.9				
	Apr.	7.2	7.4	6.7	7.0	7.3	7.8			
	May	6.4	7.0	6.7	7.0	6.5	6.4	4.7		5.6
	June	3.5	4.5	6.6	3.7	3.8	4.5			
	July	2.6		2.3	2.6	2.4				

[a] Ratios are given when Sr^{90} concentrations were 10 pc/liter or more.

monthly average Sr^{90} content of milk. Although the high and low ratios differed by a factor of 4, this ratio for a given location could be used to compute Sr^{90} concentrations to considerably better than ±50 percent in most cases. It would not be proper to generalize unduly on this empirical observation. For a given location, over a limited time period, however, this method should prove useful for quickly estimating Sr^{90} concentrations.

Table 6 contains values of the Sr^{89}/Sr^{90} ratios obtained by dividing the monthly average Sr^{89} concentration in milk by the monthly average Sr^{90} concentration in milk. After fission product formation the ratio of the amount of Sr^{89} to the amount of Sr^{90} decreases with time, reaching a value of 20 at 140 days and then dropping to a 1 to 1 ratio at 1 year. As would be expected, the observed ratio in milk changed rapidly with time. It is of interest to note, however, that, for a given month, this ratio is remarkably constant between different locations. Analytical and statistical errors could account for the small discrepancies.

Previously published data (*1–3*) show that a definite "spring peak" was observed for 1962, although it was not very pronounced except for Humboldt and Del Norte. This phenomenon showed clearly at almost all locations in 1963 (figure 6). A special word might be said about Los Angeles and San Diego. Virtually all the fresh milk for these areas is from cows that never see a fresh pasture. Most of the feed for these cattle is grown on irrigated land in the Imperial Valley, where there is virtually no rainfall.

Summary

It is clear that although most of the milk produced in California contains concentrations of Sr^{90} below the national average, the milk produced in the northernmost California milksheds has sometimes had concentrations of Sr^{90} several times that previously reported for anywhere in the U.S. In an attempt to elucidate factors which could serve to explain some of these anomalies, the Del Norte, Humboldt, and Shasta milksheds will be examined in detail during the next two years.

REFERENCES

(*1*) California Department of Public Health: California Milk Network, 1960–June 1962, *Radiological Health Data*, *4*:90–2, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (February 1963).

(*2*) California Department of Public Health: California Milk Network, July–September 1962, *Radiological Health Data*, *4*:243–244, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (May 1963).

(*3*) California Department of Public Health: California Milk Network, October 1962–March 1963, *Radiological Health Data: 4*:409, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (August 1963).

INDIANA MILK NETWORK
August 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 7).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August, 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which time the frequency of sampling is increased. Because of continued low results for the short half-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station. Should further variations be observed, an increased sampling rate will be put into effect immediately.

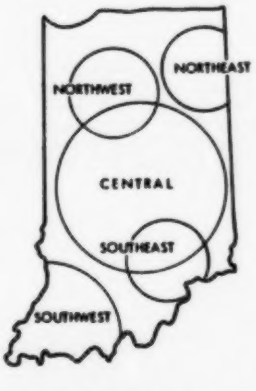

FIGURE 7.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

TABLE 7.—RADIONUCLIDES IN INDIANA MILK, AUGUST 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	<10	38	<10	125	<10
Southeast	<10	41	<10	110	<10
Central	<10	54	<10	100	<10
Southwest	<10	33	<10	70	<10
Northwest	<10	40	<10	130	<10
State average	<10	41	<10	105	<10

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 7. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium–90 in Milk by an Ion Exchange Method, *Analytical Chemistry* *33*: 1306–8 (September 1961).

NEW YORK MILK NETWORK
July 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 8), are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, cesium-137, and barium-lanthanum-140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 8.

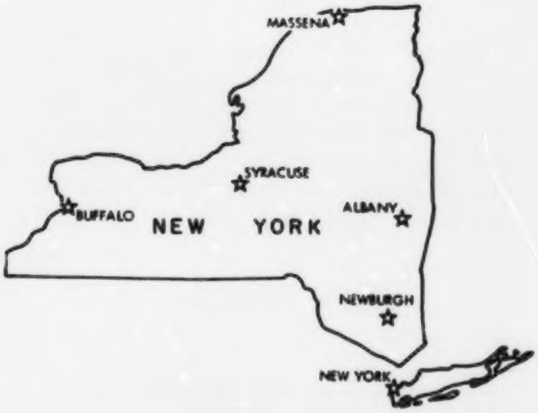

FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 8.—RADIONUCLIDES IN NEW YORK MILK, JULY 1963

[Average concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$
Albany	69	26	<20	109	<20
Buffalo	44	14	<20	117	<20
Massena	97	40	<20	224	<20
Newburgh	79	34	<20	129	25
New York City	90	29	<20	119	<20
Syracuse	59	26	<20	88	<20
Average	78	28	<20	131	<20

Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

REFERENCE

(*1*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999-R-2*, (March 1963). Single copies available on request from Public Figures Branch, PHS, Bureau of States Services, Department of Health, Education and Welfare, Washington, D.C. 20201.

CANADIAN MILK NETWORK [1]
August 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, the analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89 and cesium–137, as well as strontium–90.

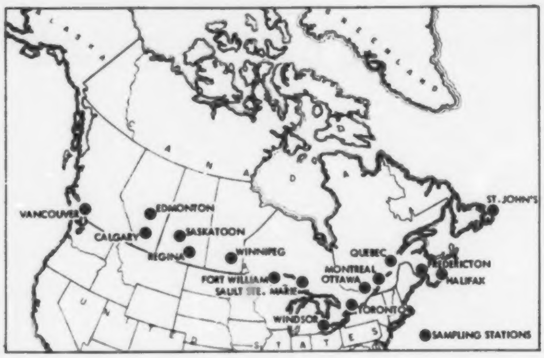

FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa for analysis. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Iodine–131 is determined on a portion of each sample; the remaining portion is combined into monthly composites for the determination of strontium–90, strontium–89 and cesium–137.

Analytical Methods

For the analysis of iodine–131, radiochemical methods (*1*) are used. Carrier iodide is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to iodine and extracted with carbon tetrachloride, back-extracted in sulphite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with a polyethylene sheet. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium is separated on an ion-exchange column (*2, 3*). The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter isotope, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray, constructed in the form of an inverted well to accommodate the 5 x 4 inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier". In the determination of cesium this factor is not involved.

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[1] Data from *Radiation Protection Programs, Vol. 1, No. 9*:20–26, Radiation Protection Division, Canadian Department of National Health and Welfare (September 1963).

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The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in reference (*4*). For example, the 2σ total errors (representing 95 percent confidence) associated with a measured concentration of 10 pc/liter, in units of pc/liter are Sr^{89}, 2.5; Sr^{90}, 1.5; I^{131}, 5; and Cs^{137}, 6.

Results

Table 9 presents monthly averages of strontium-89, strontium-90, cesium-137, iodine-131, and stable calcium in Canadian whole milk. Figures 10 and 11 show the variation of the network average radionuclide content of Canadian whole milk.

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*5*), it is necessary to keep in mind that the MPC values refer to conditions of continous exposure over a lifetime. Therefore, the average

TABLE 9.—RADIONUCLIDES IN CANADIAN WHOLE MILK, AUGUST 1963

[Radionuclide concentration in pc/liter]

Station	Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137
Calgary	1.43	130.8	68.6	3	287
Edmonton	1.30	54.3	55.0	2	206
Ft. William	1.22	82.6	43.0	4	282
Fredericton	1.31	118.4	91.8	5	453
Halifax	1.24	87.7	53.5	2	289
Montreal	1.43	65.5	42.5	1	289
Ottawa	1.39	63.7	45.9	4	202
Quebec	1.23	65.3	35.5	2	356
Regina	1.42	81.1	63.6	0	174
St. John's, Nfld	1.42	88.6	98.3	1	400
Saskatoon	1.39	83.2	44.5	2	179
Sault Ste. Marie	1.42	86.6	53.3	5	267
Toronto	1.40	20.5	14.5	8	163
Vancouver	1.36	60.8	52.2	3	333
Windsor	1.37	20.4	25.8	0	78
Winnipeg	1.39	74.8	54.5	2	196
Average	1.36	74.0	52.7	3	260

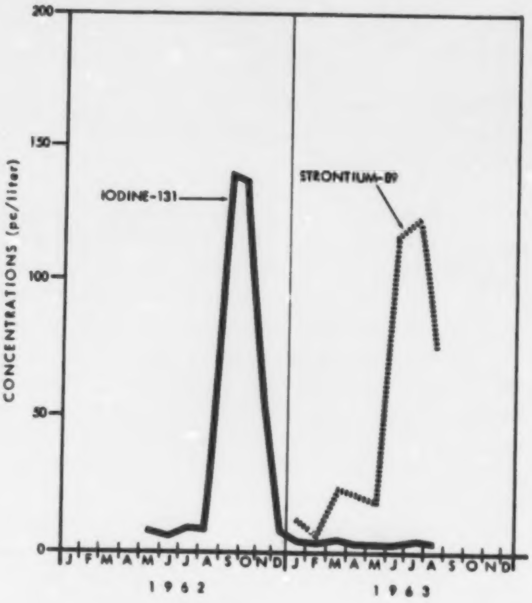

FIGURE 10.—IODINE-131 AND STRONTIUM-89 CONCENTRATIONS IN CANADIAN WHOLE MILK

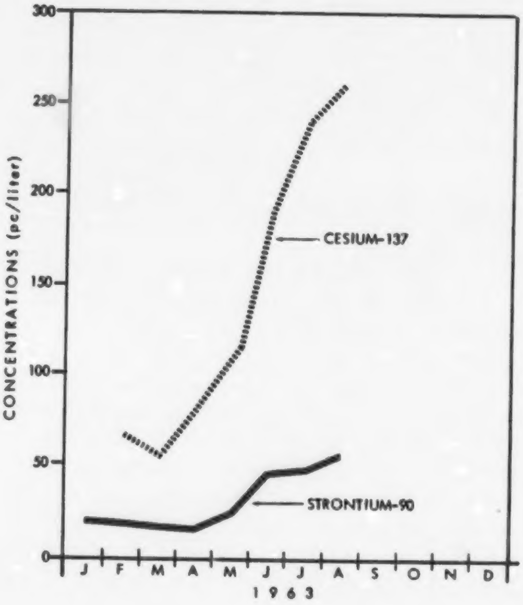

FIGURE 11.—STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

levels over an extended period such as one year represents a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) DasGupta, A.K., and H.G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, (October 1963).

(*2*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July 1958).

(*3*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare, (June 1, 1960).

(*4*) Public Health Service: Canadian Milk Network, *Radiological Health Data* *4*:561-3, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (November 1963).

(*5*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Annual Average Radionuclide Concentrations in Pasteurized Milk

September 1962—August 1963

Utilization of the radionuclide concentration values reported by the Pasteurized Milk Network (*1*) for assessing that portion of an individual's or a population's radiation dose attributable to milk consumption is dependent on determining both the annual average concentrations of specific radionuclides of interest in milk and the average daily milk intake of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium-89, strontium-90 and iodine-131 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk intake (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

Employing an assumption, that the average daily milk consumption of an individual in a population group is one liter, permits comparisons to be made between the daily rates of intake of the above radionuclides from the milk component of the diet and the Federal Radiation Council's action ranges of transient daily rates of intake (*4*). The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*)[1]. The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Table 1, consisting of annual averages of radionuclide concentrations in milk, is based on the PHS Pasteurized Milk Network monthly averages of these radionuclides. To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values, (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

The data in table 1 are calculated as follows: (*a*) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in 12 consecutive months are averaged to obtain the annual average.

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Pasteurized Milk Network, *Radiological Health Data*, *4*:551-557, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (November 1963).

(*2*) Bureau of the Census, Department of Commerce, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* *4*:15-17, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962, *Radiological Health Data*, *4*:124-7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii-iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 1962).

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[1] Upper limit of Range II corresponds to a dose on one-third of the annual RPG in the case of radioactive strontium.

TABLE 1.—ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Iodine-131		Strontium-89		Strontium-90	
		August 1962-July 1963	September 1962-August 1963	August 1962-July 1963	September 1962-August 1963	August 1962-July 1963	September 1962-August 1963
Ala:	Montgomery	17	16	66	67	18	19
Alaska:	Palmer	102	100	56	58	14	15
Ariz:	Phoenix	<10	<10	19	18	4	4
Ark:	Little Rock	38	37	135	137	37	38
Calif:	Sacramento	11	<10	42	42	8	8
	San Francisco	11	11	74	73	11	12
Colo:	Denver	13	11	30	29	13	14
Conn:	Hartford	20	20	28	30	16	18
Del:	Wilmington	31	30	42	41	20	22
D.C:	Washington	23	22	47	46	19	19
Fla:	Tampa	18	18	36	36	12	13
Ga:	Atlanta	23	22	93	92	23	25
Hawaii:	Honolulu	12	11	37	36	8	8
Idaho:	Idaho Falls	19	17	46	46	17	19
Ill:	Chicago	30	28	31	29	17	18
Ind:	Indianapolis	29	29	41	41	19	20
Iowa:	Des Moines	43	41	78	74	19	20
Kans:	Wichita	27	25	56	53	16	17
Ky:	Louisville	26	26	102	103	27	29
La:	New Orleans	27	26	150	148	34	36
Maine:	Portland	22	20	35	37	21	23
Md:	Baltimore	23	22	52	53	19	20
Mass:	Boston	21	21	39	41	25	27
Mich:	Detroit	34	32	28	29	17	18
	Grand Rapids	25	24	26	26	15	16
Minn:	Minneapolis	30	29	64	63	24	25
Miss:	Jackson	25	24	148	147	28	30
Mo:	Kansas City	41	38	90	86	21	22
	St. Louis	24	23	61	58	18	19
Mont:	Helena	34	32	54	55	19	22
Nebr:	Omaha	39	27	65	60	20	21
Nev:	Las Vegas	<10	<10	22	22	7	7
N.H:	Manchester	21	19	37	39	23	25
N.J:	Trenton	22	21	32	32	18	19
N. Mex:	Albuquerque	14	13	25	25	7	7
N.Y:	Buffalo	22	22	31	31	18	19
	New York	30	30	37	39	21	23
	Syracuse	24	24	34	34	18	20
N.C:	Charlotte	<10	<10	72	73	26	27
N. Dak:	Minot	35	33	83	85	33	37
Ohio:	Cincinnati	36	34	52	51	21	22
	Cleveland	30	29	33	34	18	18
Okla:	Oklahoma City	33	32	79	77	21	22
Ore:	Portland	23	22	111	102	21	23
Pa:	Philadelphia	28	27	38	37	20	21
	Pittsburgh	37	36	44	45	22	24
P.R:	San Juan[a]	15	15	87	87	13	14
R.I:	Providence	22	22	35	36	21	22
S.C:	Charleston	19	18	72	72	23	24
S. Dak:	Rapid City	35	34	71	70	24	26
Tenn:	Chattanooga	20	20	116	118	28	31
	Memphis	27	26	105	105	26	28
Tex:	Austin	30	30	39	39	8	8
	Dallas	49	47	92	91	19	20
Utah:	Salt Lake City	43	18	39	36	16	17
Vt:	Burlington	23	22	37	39	19	22
Va:	Norfolk	17	17	56	54	21	21
Wash:	Seattle	23	21	77	76	20	21
	Spokane	20	18	53	53	19	20
W. Va:	Charleston	16	16	76	76	26	27
Wis:	Milwaukee	36	35	29	30	14	15
Wyo:	Laramie	23	11	62	52	18	18
Network average		26	24	59	58	19.2	20.4

[a] No sample was received for November 1962.

Radionuclides in Institutional Diet Samples

April–June 1963

Division of Radiological Health,
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanges with severe economic limitations. Each institution (sampling point) except the one at Los Angeles is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

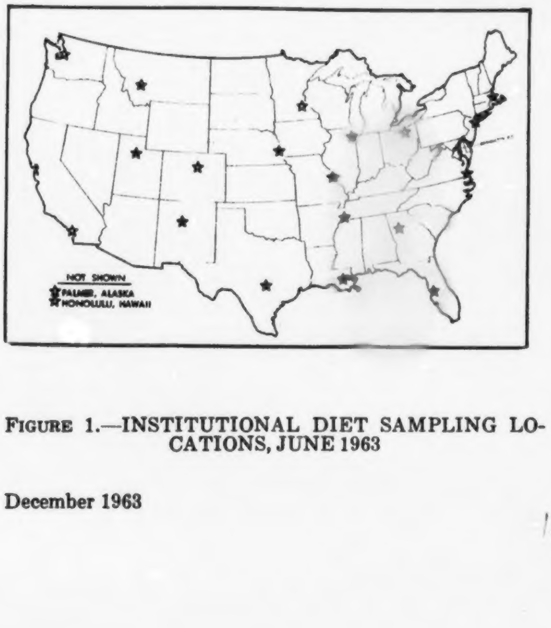

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, JUNE 1963

Sampling Procedure

In general the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collecting the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample was packaged in three containers: one containing solid food minus seeds, pits, rinds, shells and bones that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, and ice cream; and one containing soft drinks, coffee, tea and water. A record of the contents of each meal and the approximate weight of each item was made by the institution's dietician and sent with the sample. Samples usually ranged from 6 to 16 liters in volume and weighed from 8 to 20 kilograms.

Analytical Procedures

Because calcium and phosphorus compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program. Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (3) total radium analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: iodine-131, 10 pc/kg; cesium-137, 5 pc/kg; and barium-140, 10 pc/kg. Approximate minimum detectable concentrations for strontium-89, strontium-90, and total radium are: 5, 1, and 1 pc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After samples are transferred to planchets and dried, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from April 1963 through June 1963 for the 20 institutions from which samples were received. Also contained in the table is the range of ages of the children for which samples are being obtained. The reported radionuclide concentrations of these samples has been extrapolated to the end of the sample collection period. The true iodine-131 intakes therefore may be somewhat greater than the reported values.

TABLE I—INSTITUTIONAL DAILY DIETARY

	Month (1963)	Alaska, Palmer	California, Los Angeles	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis	Missouri, St. Louis	Montana, Helena
Age (years)		6-18	6-18	5-21	6-18	6-18	5-16	7-18	[a]	[b] <1-16	7-16	6-17
Total weight (kg/day)	Apr	1.31	2.59	[c]—	1.26	1.57	1.87	2.18	1.67	1 64	2.78	1.65
	May	1.21	2.48	2.76	1.94	1.72	1.76	2.01	2.19	2.19	1.65	1.19
	June	1.31	—	1.90	2.34	1.60	1.68	2.20	1.68	1.55	2.88	1.34
Calcium (g/day)	Apr	0.6	1.4	—	1.5	0.8	0.8	1.6	1.3	0.6	1.9	0.7
	May	0.6	1.5	2.2	1.2	0.9	0.9	1.4	1.8	0.7	1.5	0.5
	June	0.7	—	1.1	1.2	0.9	0.4	1.6	1.2	0.6	0.8	0.4
Phosphorus as phosphate (g/day)	Apr	2.4	7.2	—	1.0	1.1	3.3	1.8	3.5	2.9	7.8	2.9
	May	2.7	6.2	3.3	1.6	1.3	3.4	1.8	6.0	3.5	5.5	2.4
	June	2.9	—	4.1	1.4	1.3	2.2	1.8	7.0	2.3	3.0	2.4
Potassium (g/day)	Apr	2.0	4.1	—	1.6	1.3	2.8	3.1	2.8	2.8	3.9	2.3
	May	2.2	3.5	4.1	2.9	1.8	2.5	2.9	4.0	2.8	4.9	1.5
	June	2.6	—	3.0	3.0	2.1	2.0	3.4	2.5	2.6	4.6	2.0
Total radium (pc/day)	Apr	2.0	3.0	—	3.6	2.8	2.0	3.5	<1	2.0	3.0	2.0
	May	1.0	<1	<1	3.5	4.5	4.0	5.5	<1	2.0	4.0	2.0
	June	<1	—	2.0	<2	4.1	<1	<2	<1	3.0	1.0	11.0
Strontium-89 (pc/day)	Apr	5	35	—	20	50	60	220	<5	<5	110	<5
	May	<5	25	40	35	140	90	140	[d]	60	305	10
	June	15	—	15	50	70	55	260	5	95	30	10
Strontium-90 (pc/day)	Apr	13	13	—	9	16	14	51	21	21	39	9
	May	16	12	33	14	30	4	49	[d]	25	59	7
	June	18	—	24	28	25	15	31	44	34	32	11
Cesium-137 (pc/day)	Apr	70	80	—	95	60	75	230	135	105	95	40
	May	75	75	165	200	195	95	200	150	105	475	55
	June	80	—	105	185	125	95	225	210	140	230	80
Barium-140 (pc/day)	Apr	<10	<10	—	<30	<20	<10	<30	<10	<10	<10	<10
	May	<10	<10	<10	<20	<20	<10	<20	<10	<10	<10	<10
	June	<10	—	<10	<20	<20	<10	<30	<10	<10	<10	<10
Iodine-131 (pc/day)	Apr	<10	<10	—	<20	<20	<10	<30	<10	<10	<10	<10
	May	<10	<10	<10	<20	<20	<10	<20	<10	<10	<10	<10
	June	<10	—	<10	<30	<20	<10	<30	<10	<10	<10	<10

[a] Ages not available.
[b] Food samples not collected from children too young for solid diet.
[c] A dash indicates no sample collected.
[d] Sample lost.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less than" data are assumed to be equal to the full "less than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less than" values are considered to be zero.

Figure 2 shows the overall average daily intake of radionuclides at all institutions since January 1961. The data are also presented graphically in figures 3 and 4, as step charts of the number of samples collected versus daily intake. For example, total dietary intake of food is divided into eleven ranges. The number of values reported during this quarter in each range is plotted as a frequency-distribution step chart. The number of stations used in constructing these graphs was 19, 20, and 17 for the months of April, May and June 1963, respectively. Therefore, the total number of samples represented in each chart is 56.

Discussion of Data

Total intake ranged between 1.04 and 2.88 kg/day during this quarter. The frequency-distribution step chart shows that 66 percent of the samples weighed between one and two kg/day, and 14 percent of the samples weighed between 2.75 and 2.89 kg/day.

The calcium intake ranged between 0.4 and 2.2 g/day, with forty-eight percent of the values being less than one g/day while 12 percent were greater than 1.8 g/day. Phosphate intake ranged from 0.8 to 11.3 g/day, with 46 percent of the values ranging from one to 3 g/day. Potassium intake appears similar to a binomial distribution, with

INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

	Month (1963)	Nebraska, Omaha	New Mexico, Albuquerque	New York, New York	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly Minimum Average	Monthly Maximum Average
Age (years)		6–18	5–15	8–15	6–15	8–18	6–18	12–18	10–18	6–16		
Total weight (kg/day)	Apr	2.02	1.52	1.51	1.98	1.04	2.80	1.20	1.18	2.82	1.82	1.82
	May	2.78	1.72	1.30	1.87	1.35	2.86	1.41	1.15	2.62	1.93	1.93
	June	1.84	1.78	—	1.87	1.38	2.57	—	1.09	2.70	1.87	1.87
Calcium (g/day)	Apr	1.6	0.6	1.8	1.4	0.8	1.6	0.5	0.6	1.8	1.2	1.2
	May	1.9	1.2	0.8	1.5	0.8	1.4	0.4	0.6	1.8	1.2	1.2
	June	1.0	0.9	—	1.4	1.1	1.4	—	0.5	0.4	0.9	0.9
Phosphorus as phosphate (g/day)	Apr	5.0	4.0	3.5	6.1	0.8	2.2	2.2	0.8	6.7	3.4	3.4
	May	7.8	4.2	6.1	7.0	0.9	2.1	2.5	1.0	6.0	3.8	3.8
	June	4.2	2.2	—	11.3	1.2	2.0	—	0.8	3.1	3.1	3.1
Potassium (g/day)	Apr	5.1	2.6	2.4	3.4	1.8	3.5	2.0	1.5	3.9	2.8	2.8
	May	3.9	2.6	2.0	3.6	1.9	3.3	2.7	1.4	4.2	2.9	2.9
	June	2.9	3.7	—	3.1	1.7	2.9	—	1.2	4.2	2.8	2.8
Total radium (pc/day)	Apr	7.0	1.0	<1	<1	4.0	<2	1.0	1.2	3.0	2.2	2.4
	May	3.0	2.0	<1	<1	1.6	6.0	1.0	1.7	2.0	2.2	2.4
	June	<1	<1	—	<1	<2	<3	—	2.0	3.0	1.5	2.4
Strontium-89 (pc/day)	Apr	30	10	<5	<5	110	115	5	40	60	46	47
	May	110	70	20	[d]	100	60	<5	50	220	82	82
	June	105	25	—	50	115	90	—	35	185	71	71
Strontium-90 (pc/day)	Apr	23	9	15	21	18	28	7	15	30	20	20
	May	39	13	21	[d]	19	34	9	16	41	24	24
	May	59	9	—	31	27	26	—	18	40	28	28
Cesium-137 (pc/day)	Apr	180	25	100	115	40	140	50	70	170	99	99
	May	195	45	85	115	55	105	90	45	260	139	139
	June	140	20	—	155	90	135	—	45	260	136	136
Barium-140 (pc/day)	Apr	<10	<10	<10	<10	<20	<30	<10	<20	<10	0	14
	May	<10	<10	<10	<10	<20	<30	<10	<20	<10	0	14
	June	<10	<10	—	<10	<20	<30	—	<20	<10	0	15
Iodine (pc/day)	Apr	<10	<10	<10	<10	<20	<30	<10	<20	<10	0	14
	May	<10	<10	<10	<10	<20	<30	<10	<20	<10	0	14
	June	<10	<10	—	<10	<20	<30	—	<20	<10	0	15

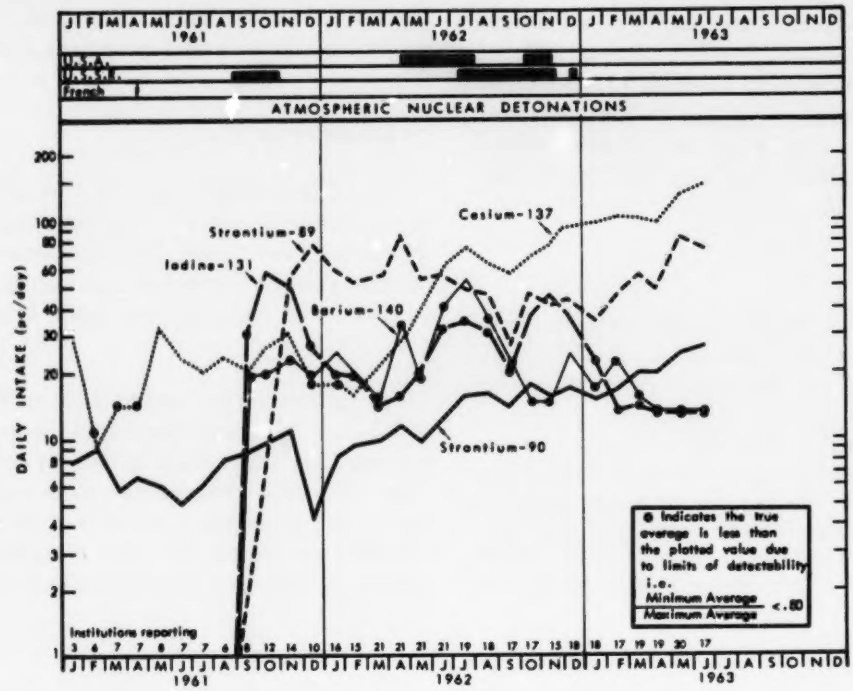

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

80 percent of the samples containing between 1.5 and 4.0 g/day.

Total radium intake ranged between less than 1 and 11 pc/day with all but four of the analyses being less than 5 pc/day.

Strontium-89 intake ranged between less-than-5 and 260 pc/day. Twenty-nine percent of the intake values were between less-than-5 and 20 pc/day. For purposes of comparison the FRC range II for strontium-89 is 200 to 2000 pc/day (*3*). The maximum strontium-90 intake during this quarter was 59 pc/day. Comparison shows that 48 percent of these values were below 20 pc/day. The FRC range II for strontium-90 is 20 to 2000 pc/day (*3*, *4*).

Although the intake of cesium-137 ranged from 20 to 475 pc/day, the distribution shows a pronounced peak between 40 and 120 pc/day formed by 55 percent of the results.

Both barium-140 and iodine-131 were below the limits of detectability during this quarter.

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52*:1391–400 (September 1962).

(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers *Annual Review of Pharmacology 1*:369–96 (1961).

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

(*4*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65 (May 1962).

Previous coverage in *Radiological Health Data:*

Period	Issue
January 1961–February 1962	*July 1962*
March–June 1962	*December 1962*
July–September 1962	*April 1963*
October–December 1963	*July 1963*
January–March 1963	*September 1963*

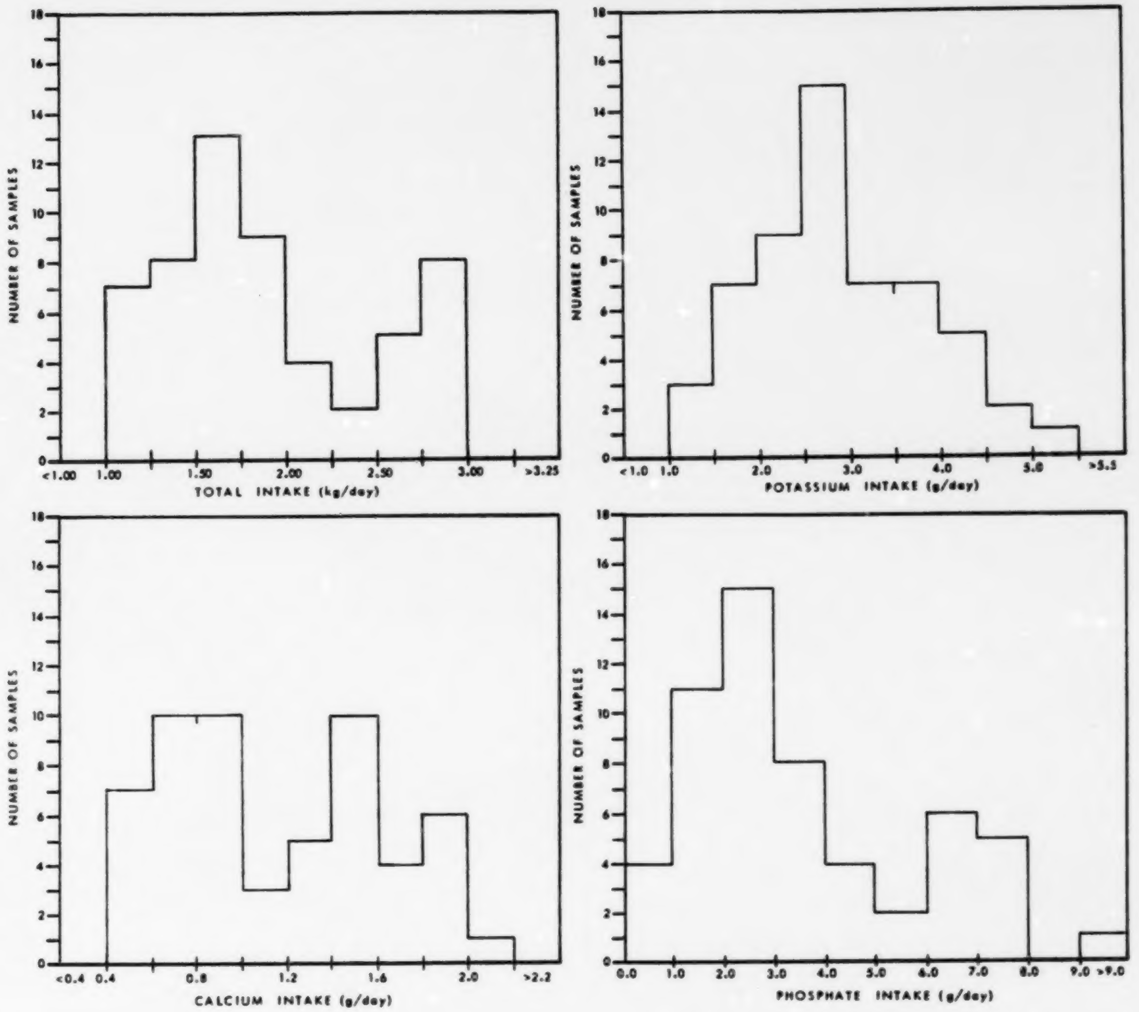

FIGURE 3.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS THE INTAKE OF STABLE MATERIALS IN INSTITUTIONAL DIETS FOR APRIL–JUNE 1963.

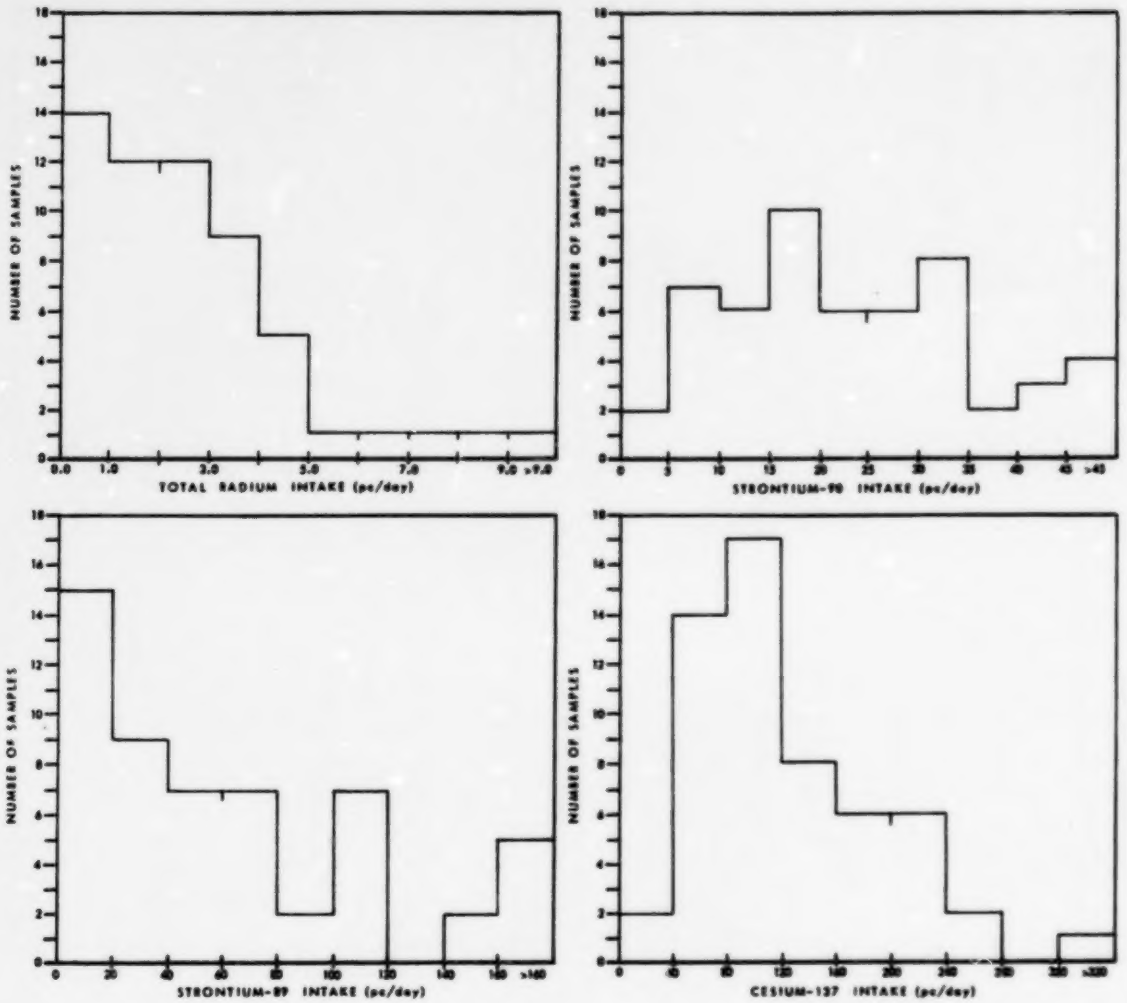

FIGURE 4.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS THE INTAKE OF RADIOACTIVE MATERIALS IN INSTITUTIONAL DIETS FOR APRIL–JUNE 1963

Tri-City Diet Study[1]

February–April 1963

Joseph Rivera [2]

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data from the "Household Food Survey of 1955" are based on a weight-as purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is deboned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for waste.

After two samplings at each city it was found that the calcium content of most food categories at these cities did not vary, nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in *HASL-113* (*1*).

Results obtained from the programs twelfth sampling (February–April 1963) are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—TWELFTH SAMPLING, FEBRUARY–APRIL 1963

Food category	Average U.S. consumption		New York City February 1963		Chicago April 1963		San Francisco March 1963	
	diet kg/yr	Calcium (g/yr)	pc/kg	pc/yr	pc/kg	pc/yr	pc/kg	pc/yr
Bakery products	37	37.0	[a]17.1 ± 1.2	633	22.5 ± 1.4	832	10.9 ± 1.1	403
Whole grain products	11	10.0	28.6 ± 1.4	315	50.1 ± 0.2	551	21.8 ± 1.2	235
Eggs	16	9.1	Lost	[b]19	3.8 ± 0.2	11	1.8 ± 0.1	29
Fresh vegetables	43	15.0	6.8 ± 0.6	292	9.5 ± 0.5	409	1.9 ± 0.4	82
Root vegetables	17	6.1	11.6 ± 0.5	197	5.9 ± 0.5	100	4.7 ± 0.3	80
Milk	221	234.3	11.4 ± 0.5	2,519	9.6 ± 0.5	2,119	7.6 ± 0.3	1,680
Poultry	17	9.2	3.7 ± 0.1	63	2.6 ± 0.2	44	2.1 ± 0.2	36
Fresh fish	8	10.8	2.4 ± 0.1	19	0.5 ± 0.1	4	1.3 ± 0.1	10
Flour	43	8.6	18.0 ± 0.5	774	10.8 ± 0.5	462	3.6 ± 0.2	155
Macaroni	3	0.7	10.1 ± 0.4	30	17.2 ± 0.5	51	8.3 ± 1.6	25
Rice	3	1.1	1.9 ± 0.2	6	2.8 ± 0.3	8	1.6 ± 0.3	5
Meat	73	10.9	0.9 ± 0.1	66	1.3 ± 0.1	94	1.6 ± 0.1	117
Shellfish	1	0.8	1.4 ± 0.2	1	1.0 ± 0.2	1	1.0 ± 0.1	1
Dried beans	3	2.9	13.2 ± 1.6	40	30.2 ± 1.7	90	9.4 ± 1.4	28
Fresh fruit	68	13.6	19.2 ± 0.6	1,307	2.7 ± 0.3	182	3.4 ± 0.2	214
Potatoes	45	5.8	5.0 ± 0.6	225	3.3 ± 0.4	148	1.7 ± 0.3	76
Canned fruit	26	1.3	1.1 ± 0.1	29	1.5 ± 0.1	39	1.9 ± 0.2	49
Fruit juices	19	1.7	2.9 ± 0.2	55	4.2 ± 0.2	80	2.3 ± 0.4	44
Canned vegetables	20	4.2	6.8 ± 0.3	136	6.1 ± 0.5	121	2.5 ± 0.6	50
Annual intake	674	283		6,726		5,346		3,309
pc Sr^{90}/g Ca in total diet				18		14		8.6

[a] Error terms are one standard deviation (due to counting).
[b] Estimated from November 1962 sampling.

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[1] Summarized from *Fallout Program Quarterly Summary Report, HASL 140*:163–165, Office of Technical Services, Department of Commerce, Washington 25, D.C., (October 1963), price $3.50.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

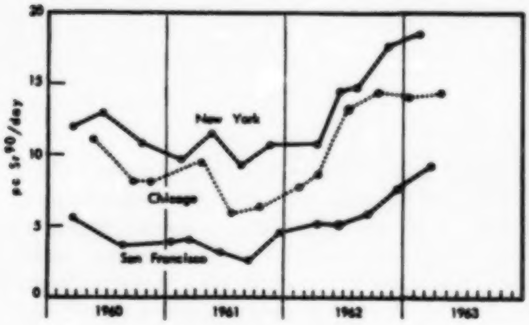

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

Discussion

The trend of increasing daily intake of strontium-90 at each of the three cities, which started after the resumption of atmospheric testing of nuclear weapons by the U.S.S.R. in September 1961, is seen in figure 1 to have continued through the winter of 1962–1963. The previously noted geographic pattern of distribution of strontium-90 in the diet is seen to persist in the last sampling: New York City has the highest levels. San Francisco the lowest while Chicago has intermediate levels. Partly due to its high annual consumption, milk continues to be the predominant source of strontium-90 in the diet.

REFERENCES

(1) J. Rivera: *Fallout Program Quarterly Summary Report, HASL-113*:85–89, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1961), price $2.50.

Recent coverage in *Radiological Health Data:*

Period	Issue
Seventh sampling (November 1961 February 1962)	*September 1962*
Eighth sampling (April 1962)	*January 1963*
Ninth sampling (June–July 1962)	*March 1963*
Tenth sampling (August–September 1962)	*June 1963*
Eleventh sampling (November–January 1963)	*September 1963*

Strontium-90 and Cesium-137 Content of Beef and Beef Products, 1960–1962

Meat Inspection Division, U.S. Department of Agriculture

A small-scale surveillance program to determine the concentrations of strontium-90 and cesium-137 in meat from various geographical areas of the United States was initiated by the U.S. Department of Agriculture (USDA) in 1960. Approximately four-pound samples of beef rib meat were removed from cattle carcasses by the Department's meat inspectors at the time of slaughter. These samples were then chilled and air-mailed to the USDA laboratory. The samples were ashed at 450°-500° and the ash was then sent to a contract laboratory for analysis of strontium-90 and cesium-137. The ash was fused with sodium carbonate. The residue was then dissolved in hydrochloric acid, the strontium and calcium were precipitated as oxalates, and the cesium was precipitated as phosphomolybdate.

Laboratory procedures for determining strontium-90 involved: separating the strontium from the calcium with concentrated nitric acid, scavenging the radium and lanthanides with barium chromate, isolating the yttrium-90 after secular equilibrium, plating on a planchet and measuring the activity in a thin-window gas-flow proportional counter.

The final steps in the cesium-137 procedure involved plating the phosphomolybdate precipitate on a planchet and measuring the activity in a thin-window gas-flow proportional counter.

Beef

Strontium-90 and cesium-137 contents of beef samples are shown in table 1, according to slaughtering location and slaughtering date. The city indicated is not necessarily the point of origin of the cattle.

Soup Stock

In 1961, the program was altered to analyze simulated beef soup stock for strontium-90 and cesium-137. Beef bones with a small amount of meat adhering were digested in an open kettle over an extended period of time to determine degree of transfer of radionuclides from bone to solution.

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TABLE 1.—STRONTIUM-90 AND CESIUM-137 IN BEEF RIB MEAT, 1960

[Concentrations in pc/kg wet weight]

Slaughter point		Collection interval (1960)	Strontium-90			Cesium-137		
			Number of samples	Average	Range	Number of samples	Average	Range
California:	San Francisco	6/30—8/16	4	2.0	1.0- 5.0	4	2.0	1.0- 3.0
	Stockton	6/30—7/21	4	1.2	1.0- 2.0	4	4.5	1.0- 6.0
Georgia:	Atlanta	8/5 —8/25	5	5.2	3.6- 9.8	5	9.7	1.1-32.4
Iowa:	Glenwood	6/4	1	14.0		0		
	Sioux City	7/18	1	13.0		1	2.0	
Maryland:	Baltimore	8/15—8/22	5	4.0	0.8- 8.8	5	6.7	0.2-21.6
Minnesota:	St. Paul	7/18—8/10	8	2.9	0.4-10.2	8	2.4	0.2- 5.2
Nebraska:	Omaha	4/6 —4/25	11	3.2	0.8- 8.2	11	0.6	0.1- 2.9
Nevada:	Reno	7/1	1	1.2		1	9.3	
Oregon:	Portland	6/14	1	2.0		1	1.0	
Pennsylvania:	Harrisburg	4/29	1	1.0		1	0.2	
Texas:	Ft. Worth	7/18—8/8	11	2.5	1.0- 5.2	10	4.7	0.2-14.8
Washington:	Seattle	5/24—7/5	26	2.2	0.5- 6.7	22	5.3	0.2-18.5
	Tacoma	5/23—6/7	4	16.0	8.0-33.0	3	3.7	1.0- 9.0

TABLE 2.—STRONTIUM-90 AND CESIUM-137 IN BEEF SOUP STOCK, 1961

[Concentrations in pc/kg solution[a]]

Collection point	Collection date (1961)	Number of samples	Strontium-90		Cesium-137	
			Average	Range	Average	Range
Camden, New Jersey	October 11	13	2.2	0.9-5.2	13.4	1.9-27.3

[a] Concentration in soup stock solution after digestion of bones and meat.

The liquor, representing the cooked water extract of the bones and the adhering meat, was then ashed and analyzed for strontium-90 and cesium-137 using the same procedure as for beef rib meat through the step of precipitating the calcium and strontium as oxalates and precipitating the cesium as a phosphomolybdate. The precipitates were then plated onto separate planchets and counted in a thin-window gas-flow proportional counter without further processing.

Strontium-90 and cesium-137 found in the beef stock are expressed in table 2 as pc/kg stock solution. Thirteen samples were collected at Camden, New Jersey, although the cattle probably originated in other areas of the country. An undetermined part of the radionuclide levels found could have been contributed by the water during cooking. It is felt that the results represent the highest degree of contaminant extraction likely in soup stocks.

Meat Products

Since most of the ingredients used by the meat packing industry are found in meat products, the sampling program was altered in 1962 to include the analysis of meat products. The samples were ashed and the analytical procedure was carried out in a manner similar to that for beef rib meat except in the final steps. After the radium and lanthanides had been scavenged, the yttrium-90 was extracted with tributyl phosphate (TBP) and the activity was measured in a thin-window gas-flow proportional counter.

Strontium-90 concentrations in meat products are arranged alphabetically in table 3 by product sampled and city of processing. The results probably reflect the upper levels of strontium-90 contamination to be encountered in meat products.

TABLE 3.—STRONTIUM-90 IN MEAT PRODUCTS, 1962

Product and sampling point	Number of samples	Collection dates (1962)	Strontium-90 concentration (pc/kg original material)
Bologna, all meat			
California: San Francisco	1	July	5.1
Louisiana: Springhill	1	July	3.0
Bologna with cereal			
Minnesota: St. Paul	1	July 30	0.7
Bologna with nonfat dry milk			
Minnesota: St. Paul	2	July, Aug 1	[a]1.6 (1.4-1.8)
Frankfurters, all meat			
D.C.: Washington	1	August 1	1.8
Minnesota: St. Paul	1	July 31	1.4
Frankfurters with cereal			
California: Los Angeles	1	July	2.7
Frankfurters with nonfat dry milk			
Texas: Fort Worth	1	July 30	0.2

[a] Actual values indicated in parentheses.

SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
June 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 127 stations as of October 1963 (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity in which the population may be subjected. Data assembled through the network are published in an annual compilation (*1–6*).

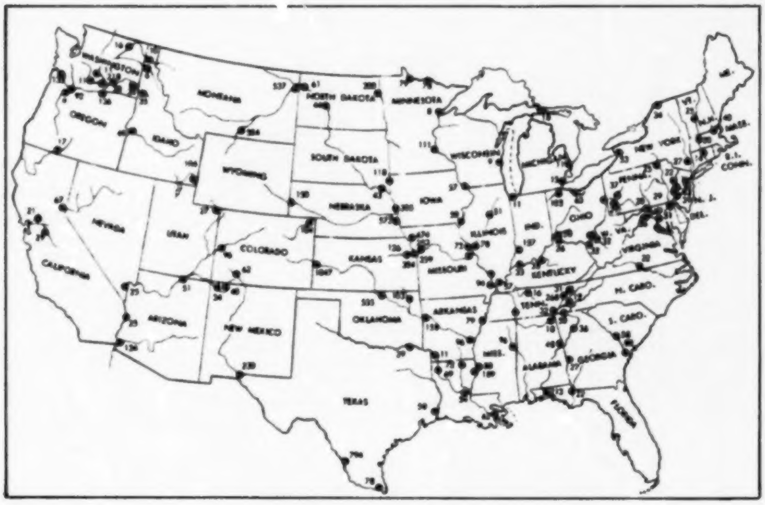
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEW YORK
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
IND.
OHIO
KENTUCKY
VIRGINIA
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
GEORGIA
ALABAMA
MISS.
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, JUNE 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in pc/liter]

Station	June 1963					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	14	23	37	0	0	0
Animas River: Cedar Hill, N. Mex	13	27	40	0	1	1
Apalachicola River:						
Chattahoochee, Fla	2	20	22	0	<1	<1
Arkansas River:						
Coolidge, Kans	896	151	1,047	58	24	82
Ponca City, Okla	445	110	555	5	3	8
Fort Smith, Ark	81	77	158	2	0	2
Pendleton Ferry, Ark	38	58	96	7	1	8
Bear River: Preston, Idaho	24	80	104	0	2	2
Big Horn River:						
Hardin, Mont	454	50	504	40	3	43
Big Sioux River: Sioux Falls, S. Dak	48	70	118	1	4	5
Chattahoochee River:						
Atlanta, Ga	24	12	36	0	0	0
Columbus, Ga	12	15	27	0	0	0
Lanett, Ala	32	16	48	1	0	1
Chena Slough:						
Fairbanks, Alaska	11	14	25	1	0	1
Clearwater River:						
Lewiston, Idaho	20	15	35	0	0	0
Clinch River:						
Clinton, Tenn	16	15	31	<1	1	1
Kingston, Tenn	85	183	268	2	1	2
Colorado River:						
Loma, Colo	35	61	96	2	6	8
Page, Ariz	5	46	51	<1	9	9
Boulder City, Nev	2	23	25	0	2	2
Parker Dam, Calif-Ariz	2	23	25	0	6	6
Yuma, Ariz	7	127	134	0	10	10
Columbia River:						
Northport, Wash	6	10	16	0	0	0
Wenatchee, Wash	0	11	11	0	0	0
Pasco, Wash	33	185	218	0	0	0
McNary Dam, Ore	28	108	136	0	0	0
Bonneville, Ore	38	54	92	—	—	—
Clatskanie, Ore	39	96	135	0	0	0
Cumberland River:						
Clarksville, Tenn	3	13	16	0	1	1
Connecticut River:						
Wilder, Vt	5	20	25	0	1	1
Northfield, Mass	3	17	20	0	0	0
Enfield Dam, Conn	6	8	14	0	0	0
Cuyahoga River:						
Cleveland, Ohio	6	59	65	<1	1	1
Delaware River:						
Martins Creek, Pa	5	17	22	0	0	0
Trenton, N. J	11	19	30	1	1	2
Philadelphia, Pa	16	32	48	1	1	2
Escambia River:						
Century, Fla	164	49	213	18	0	18
Great Lakes:						
Duluth, Minn	0	8	8	0	0	0
Sault Ste. Marie, Mich	5	13	18	0	0	0
Milwaukee, Wisc	1	8	9	0	0	0
Gary, Ind	0	11	11	0	1	1
Port Huron, Mich	4	7	11	0	1	1
Detroit, Mich	1	14	15	0	0	0
Buffalo, N. Y	33	20	53	0	0	0
Green River: Dutch John, Utah	1	26	27	0	3	3
Hudson River: Poughkeepsie, N. Y	0	27	27	0	1	1
Illinois River:						
Peoria, Ill	4	47	51	0	1	1
Grafton, Ill	28	45	73	1	2	3
Kanawha River: Winfield Dam, W. Va	16	16	32	0	1	1
Klamath River: Keno, Ore	0	17	17	0	0	0
Kansas River: De Soto, Kans	52	74	126	4	3	7
Maumee River:						
Toledo, Ohio	18	85	103	1	<1	1
Little Miami River:						
Cincinnati, Ohio	18	40	58	0	0	0
Merrimack River:						
Lowell, Mass	15	25	40	0	0	0
Mississippi River:						
St. Paul, Minn	19	92	111	1	1	2
Dubuque, Iowa	11	46	57	0	0	0
Burlington, Iowa	13	37	50	0	1	1
E. St. Louis, Ill	31	47	78	2	2	4
Miss. River—Cont.						
Cape Giraudeau, Mo	55	39	94	4	2	6
W. Memphis, Ark	47	32	79	2	0	2
Vicksburg, Miss	52	36	88	3	0	3
Delta, La	164	25	189	29	1	30
New Orleans, La	33	29	62	1	1	2
Missouri River:						
Williston, N. Dak	20	41	61	1	2	3
Bismarck, N. Dak	9	35	44	0	1	1
Yankton, S. Dak	1	42	43	0	2	2
Omaha, Nebr	156	49	205	47	6	53
St. Joseph, Mo	615	59	674	78	11	89
Kansas City, Kans	295	64	359	6	3	9
Missouri City, Mo	201	52	253	18	3	21
St. Louis, Mo	248	56	304	13	4	17
Monongahela River:						
Pittsburgh, Pa	5	24	29	0	0	0
North Platte River:						
Henry, Nebr	69	81	150	1	24	25
Ohio River:						
Huntington, W. Va	9	23	32	1	0	1
Cincinnati, Ohio	3	23	26	0	0	0
Louisville, Ky	12	26	38	0	1	1
Evansville, Ind	8	25	33	0	0	0
Cairo, Ill	28	29	57	3	0	3
Ouchita River:						
Bastrop, La	28	44	72	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	9	10	0	0	0
Platte River: Plattsmouth, Nebr	490	83	573	50	3	53
Potomac River:						
Williamsport, Md	4	16	20	0	0	0
Great Falls, Md	22	29	51	1	0	1
Rainy River:						
Baudette, Minn	16	63	79	0	1	1
International Fls., Minn	24	54	78	0	0	0
Red River, North:						
Grand Forks, N. Dak	146	154	300	13	3	16
Red River, South:						
Denison, Tex	2	27	29	0	0	0
Index, Ark	0	11	11	0	0	0
Bossier City, La	21	48	69	1	1	2
Alexandria, La	6	48	54	0	0	0
Rio Grande River:						
Alamosa, Colo	24	38	62	0	2	2
El Paso, Tex	149	81	230	7	2	9
Laredo, Tex	738	56	794	36	2	38
Brownsville, Tex	36	42	78	4	2	6
Roanoke River: John H. Kerr Resr. & Dam, Va	7	15	22	0	1	1
Sabine River: Ruliff, Tex	23	35	58	1	0	1
Sacramento River:						
Courtland, Calif	14	7	21	1	0	1
San Joaquin River:						
Vernalis, Calif	9	20	29	1	0	1
San Juan River: Shiprock, N. Mex	5	29	34	1	6	7
St. Lawrence River:						
Massena, N. Y	6	28	34	0	0	0
Schuylkill River:						
Philadelphia, Pa	14	25	39	1	1	2
Savannah River:						
North Augusta, Ga	34	24	58	0	0	0
Port Wentworth, Ga	33	55	88	0	0	0
Shenandoah River:						
Berryville, Va	20	16	36	0	0	0
Ship Creek: Anchorage, Alaska	0	13	13	0	0	0
Snake River:						
Ice Harbor Dam, Wash	5	15	20	0	0	0
Wawawai, Wash	1	19	20	0	1	1
Payette, Idaho	23	26	49	1	2	3
South Platte River:						
Julesburg, Colo	11	93	104	0	28	28
Spokane River: Post Falls, Idaho	0	6	6	0	0	0
Susquehanna River:						
Sayre, Pa	8	17	25	0	1	1
Conowingo, Md	7	22	29	0	0	0
Tennessee River:						
Lenoir City, Tenn	10	9	19	1	0	1
Chattanooga, Tenn	10	40	50	0	0	0
Bridgeport, Ala	0	18	18	0	0	0

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in pc/liter]

Station	June 1963					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Pickwick Landing, Tenn	13	19	32	1	0	1
Tombigbee River: Columbus, Miss	70	26	96	2	0	2
Truckee River: Farad, Calif	48	19	67	0	0	0
Verdigris River: Nowata, Okla	56	47	103	2	0	2
Wabash River: New Harmony, Ind	113	44	157	5	1	6

Station	June 1963					
	Beta activity			Alpha activity		
	Suspended	Susolved	Total	Suspended	Susolved	Total
Willamette River: Portland, Oreg	2	2	4	0	0	0
Yakima River: Richland, Wash	0	11	11	0	1	1
Yellowstone River: Sidney, Mont	496	41	537	35	2	37
Maximum	496	185	1,047	78	28	89
Minimum	0	2	4	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (*6*).

The participating agencies collect weekly one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known-count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Since that time a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents June 1963 results of alpha and beta analyses of U.S. raw surface waters. These preliminary; reanalysis of some samples and some analyses which are not complete at the time of this report will be included in the network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver *et al* (*9*).

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Three low-yield underground nuclear detonations at the Nevada Test Site during November 1963 were reported by the Atomic Energy Commission. Arbitrary reference numbers 143, 144, and 145 were assigned by *Radiological Health Data* in respective order of the test dates, November 14, 15, and 22. (Low yield range has been defined as less than 20 kilotons.)

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